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The Study of Metals.

If one stops to consider the number of known metals, even the number of those which are rather widely distributed, it seems strange that some of them have not been more adequately investigated. With the metallurgical resources now at command it is feasible to get in a state of purity and in reasonable quantity many metals which once ranked only as curiosities. Some few of them have been worked up for special purposes with excellent results. For example, one may note the extraordinary qualities displayed by tantalum, investigated by Dr. von Bolton in the search for incandescent lamp material. If not used to the limit of supply for this purpose it may well serve as a substitute for platinum and iridium in some of their important uses. One must also consider the use of vanadium in steel, frequently heard of in automobile circles, and the little known use of uranium in steel worked up in the Krupp factory and kept very quiet. Tungsten is becoming a familiar word, and other of the rarer elements are being heard from.

Finding direct uses for uncommon elements is, however, only a small part of the game. There are immense possibilities in alloys which are as yet untouched. Suppose, for instance, that one could find an alloy that would bear the same relation to aluminum that steel does to carbon or bronze to tin. The result would be a new structural material of immense importance in mechanical work. The builders of light machinery are looking for just this thing and with it the narrow gap that now exists between failure and success in airships might readily be crossed. Possibly there may be in the list of waiting alloys one of remarkable thermo-electric properties which would be invaluable for scientific work even if too expensive for large commercial operations. Equally useful in science would be a substance of good mechanical properties having a very low coefficient of expansion, to say nothing of one having the same coefficient as glass and making a good joint through it. The experience with tantalum shows very plainly that while some of the properties of rare elements may be accurately predicted by Mendeleeff's law, in the case of groups which are rather imperfectly known the data are uncertain and properties of a somewhat unexpected kind may be found. It is certainly worth while for the scientific forces to attack the rarer elements in a thorough and systematic way and endowment of research to this end would be a good deed for humanity. Nobody can say definitely what will be the rare elements of to-morrow, for demand sufficient to call attention to the desirability of finding ores is more than likely to lead to discoveries. Some fine day even a mineral rich in radium is likely to turn up and break the price from dollars to cents a milligram. Perhaps some one may get enough ore to prepare the actual metal. It is time that the elements should be gone over with modern resources and their properties determined, for there are still many which are practically unknown quantities, especially with respect to their relations to others and to the arts.

The Collapse of the Locust Point Pier.

The collapse of any engineering work involving a loss of $400,000 worth of property and seven lives is a subject of serious consideration in any event and particularly so when the apparent cause is the yielding of anything so well understood and long used as a pile foundation. A report of this collapse was printed in The Engineering Record last week. While that account is clear as to the main results there are some features of the action of the pile foundation of the pier which it would be most pertinent to the cause of the disaster to have set forth in greater detail than has yet been practicable. Timber pile foundations are by no means new or untried, nor is there any obscurity about their carrying power or any lack of data regarding it which can be supplied by experimental investigation, or by actual experience with them.

In this instance a rather heavy, although not excessively heavy, pier structure was being built to afford provision for the interchange of railway and steamship freight traffic of the heaviest class, carried in vessels of the deepest draught entering the port of Baltimore. The water was naturally shallow at the location of the pier, making it necessary to dredge for the requisite depth of 35 ft. The material to be dredged apparently consisted largely, if not entirely, of mud, silt and sand down to what was assumed to be hard bottom, at a depth of about 55 ft. About ten thousand 60-ft. piles were driven for the foundation in transverse rows, about 4 ft. apart. One would certainly suppose at first sight that such a foundation should have sufficient supporting power at least to sustain safely the superstructure designed to rest upon it; especially when it is stated that while the maximum load to be carried by a pile was to be 20 tons, the actual load at the time of failure was but about 9 tons. Assuming all these physical facts to be true, and there seems to be no reason for doubting them, it is a matter of much professional importance, to say nothing of anything else, to ascertain the real cause of the collapse.

It is essential at once to observe that while bottom too hard to be penetrated by a pile was 55 ft. below the water surface, the material was dredged to a depth of 35 ft. to accommodate ships berthed alongside the pier. There would thus be left about 20 ft. of sandy material in which foundation piles were to be driven. Unless resort was made to some unusual means of laterally bracing the piles below the water surface, to which no allusion has been made in the accounts so far given of the collapse, there would be a length of pile of about 35 ft. unstiffened by such bracing.

It is often specified that piles shall be driven to rock or other hard impenetrable material, in case it can be reached, without premising that there must be sufficient penetrable material overlying it to give the piles the lateral support imperatively necessary to enable them to sustain their load in a vertical position, especially if there is much unbraced length above the material in which they are driven. If this lateral support is lacking there is little to prevent all the piles in a transverse row pivoting parallel to each other about their points. If they were fully braced down to the top of the material in which they are driven, obviously the tendency to pivot would be largely if not entirely prevented. This pivoting motion or parallel lateral movement of the piles will frequently take place under comparatively small loads, depending largely upon the depth and consistency of the material overlying the rock or other hard bottom.

Again these piles would scarcely average as much as 12 in. in diameter throughout the 35 ft. of unbraced length. The stiffness of a solid timber compression member whose length is 35 times its diameter or more, is not great, and that lack of stiffness is much aggravated in the case of timber piles, which are never straight, and whose curvatures or bends are frequently both irregular and of large amounts. It would require but relatively small loads to distort severely such unbraced lengths of piles and to produce a lateral displacement of the tops of a transverse bent which would result in just such a failure as that disclosed in the accident at Locust Point. A slow lateral motion of the pier structure took place for several days before the final collapse, precisely as would have been expected under the circumstances described above.

On account of the importance of the subject, the engineers of the structure would render valuable service to designers of such piers by making public a statement of the measures taken to secure lateral stiffness of the transverse pile bents throughout the 35 ft. between water surface and the dredged bottom alongside the pier. It would also be useful to know whether the piles showed vertical settlement before lateral motion took place, and whether a greater depth than 35 ft. was reached in dredging. If conditions favorable to the pivoting or lateral rocking of the piles existed along one side of the pier only it would probably not be necessary to look farther for the real cause of the accident. It may be assumed that the structure was designed in the light of accepted practice, and the mere fact of its collapse indicates the desirability of revising what may be termed standard plans for such piers. Collapses of less important piers have occurred elsewhere which indicate that probably more bracing of piles is desirable than has usually been considered necessary.

Keeping Power Plant Data.

There are certain data in every commercial power plant which should be promptly available when needed. The principal dimensions of the engine, boiler and pump rooms, the capacities, speeds and cylinder measurements of engines, height and inside diameter of stacks, heating surface of boilers, cooling surface of surface condensers and sizes of important pipe runs are some of the statistics which many engineers carry in their heads, but, in many cases, are not properly filed for quick reference. Unless these data and other facts of the same general character are collected in a loose-leaf book, on a series of blue prints or in card index form, considerable time is liable to be lost by executive officers of the company who are seeking information by telephone or personal interview in reference to the purchase of supplies, payment of checks on contracts, or other business matters.

In a plant recently visited, the chief engineer keeps an alphabetical loose-leaf book with the special object of having at a moment's call all the fixed physical data of the station. Anything one desires to know, from the width of the cooling tower fan to the diameter and stroke of the engine cylinders is instantly available. The company's business is not impeded by long delays at the telephone while the "chief" rummages through various discarded cracker boxes and bench drawers in search of the needed facts. When a company operates a system large enough to require more or less accurate drafting to be done, it may be worth while to prepare letter-size sketches of machinery outlines for each installation, with dimensions and important sizes of apparatus attached. It often happens that changes in the plant's design have resulted in alterations of the piping. These alterations may be shown on construction drawings without reference to the original installation on the balance of the equipment, and in such cases it usually happens that there is no comprehensive plan of the completed piping. Detailed drawings of this kind are difficult to make in many instances, and they cost good money if they are executed with scrupulous care as to inter-relation and position. The essential facts can be shown just as well by a rough diagrammatic sketch, properly labelled for varying sizes and cross-marked for valve location. It is a decided help to new men in the plant to be able to study pipe layouts from a sketch of this kind.

The Kansas-Colorado Water Decision.

On Monday of this week the famous irrigation case of Kansas against Colorado was dismissed by the United States Supreme Court. The former State sought to have the latter enjoined from diverting any more of the waters of the Arkansas River for irrigating purposes or permitting its citizens to do so. The United States was represented in the case as an intervener. It has generally been admitted that the litigation was one of the most important proceedings before the Supreme Court for many years, for it deals with the relations between States and the Federal Government and vitally concerns the development of irrigation works in the West. The nature of the litigation has already been explained in this journal, and for that reason it is unnecessary to outline it at any length at this time. Kansas alleged that irrigation in Colorado with water from the Arkansas River had caused such a great permanent reduction in the volume of that stream as to destroy its navigability, diminish its availability for power purposes and lower the surface of underground water in its valley about 5 ft., thus greatly diminishing the amount of water available for irrigation in Kansas. The latter State asked for an injunction against any further appropriation of the waters of the stream in Colorado and for a recognition of the priority of right on the part of the Kansas ditches compared with those built in Colorado. The State placed great reliance on the common-law doctrine that a lower riparian owner has the right to the full natural flow of a stream. It will be seen, therefore, that the litigation practically involves the important principles of interstate water rights, together with the vital principle of ownership of water for irrigation purposes. All these questions have remained undetermined by a Federal court of high jurisdiction and for this reason the decision was expected to be of a very important nature.

Those who have followed the case at all know that very interesting and important testimony was given on the side of the State of Colorado to show that the return or seepage water from irrigating ditches in that State counterbalances the direct appropriation of water from the river. In other words, this return water percolating through the sand beds along the Arkansas River valley really serves to equalize the available underground water resources in Kansas, and was not to be regarded in any sense as a serious matter. Testimony was given by Prof. Elwood Mead, Prof. L. C. Carpenter and others to the effect that irrigation on a large scale in Colorado has had the effect of gradually extending eastward into Kansas what might be called the perennial flow of the Arkansas River in Colorado. So far as the underflow in the river valley in Kansas is concerned, witnesses from that State testified that from Garden City to Arkansas City there was no change in the normal level of the underflow as a result of irrigation in Colorado. Colorado also introduced testimony to prove that there was actually an increase of water in the Kansas ditches during dry years as a result of irrigation in Colorado. The expert testimony on this subject forms a very interesting summary of experience with irrigation waters in that part of the country, but in spite of its importance the Supreme Court decided that the appropriation of the waters of the Arkansas by Colorado had diminished the flow of water into the State of Kansas. It decided that the influence of this diminution of the river flow had been of perceptible injury to portions of the Arkansas Valley lying in Kansas, particularly those parts next the Colorado boundary line; yet the great body of the valley had received so little injury that, with regard to the interest of both States and the right of each to receive benefits through irrigation and in any other manner through the waters of this stream, the court reached the opinion that Kansas had not made out a case entitling it to an injunction. This decision was rendered without prejudice to the right of Kansas to renew its petition whenever it can be shown that the State is being substantially injured by irrigation in Colorado.

This decision is particularly interesting, so far as the abstracts of it indicate, on account of the fact that it leaves it possible still to prove that return water may practically prevent damages from the diversion of water for irrigation purposes farther up the stream. While the testimony on this point in this particular case has apparently not been given the weight by the court which it would doubtless receive from engineers, nevertheless the decision is of value as indicating the manner in which a similar point must be taken up in expert testimony in future cases.

It was hoped that the decision would throw some light on the subject of interstate water rights, and also on the priority of ownership in water used for irrigating purposes. On both of these subjects the decision is apparently very vague. So far as interstate rights are concerned, the court rules that each State has full jurisdiction over the lands within its borders, including the beds of streams and other waters. It may determine for itself whether the common law rule in respect to riparian rights or that doctrine which obtains in the arid districts of the West of the appropriation of waters for the purpose of irrigation, shall control. The decision states that Congress cannot enforce either rule on any State. It will be interesting to see whether this decision will result in future litigation, or whether the two States will be able to work together in harmony and devise some mutually satisfactory procedure. "It is obvious," the decision reads, "that if the depletion of the waters of the river by Colorado continues to increase, there will come a time when Kansas may justly say there is no longer any equitable division of benefits, and may rightfully call for relief against the action of Colorado, its corporations and citizens, in appropriating the waters of the Arkansas for irrigation purposes." This wording apparently leaves the question of interstate rights exactly where it was before the case came up; that is to say, entirely in the dark.

So far as the application of the common law to questions of irrigation is concerned the question that arose was between two States, one recognizing generally the common law rule of riparian rights and the other prescribing the doctrine of the public ownership of flowing water. Under the decision of the Supreme Court, neither State can legislate for or impose its own policy upon the other. Moreover, Congress cannot determine the rule which shall control between the two States in the case of a stream flowing through them. Just what relief a court can give in such case is something of a conundrum, which the Supreme Court has answered substantially as follows: Colorado could not be upheld in appropriating the entire flow of the Arkansas River on the ground that it is willing to give and does give to Kansas something else, a regulated underflow, which might be considered of equal value. That would be equivalent to the court making a contract between the two States, which is not authorized by the constitution. The court rules that it is justified in looking at the quesion in a broad way, not confining itself solely to the amount of flow in the channel of the river nor inquiring simply whether any portion of this flow is appropriated by Colorado, but considering, in case a portion of the flow is appropriated by Colorado, what are the effects of such an appropriation upon the territory of Kansas. As Kansas recognizes the right of appropriating the waters of a stream for irrigation, subject to the condition of an equitable division between the riparian proprietors, the court decides that she cannot complain if the same rule is administered between herself and a sister State. This is considered particularly true when the waters are, except for domestic purposes, practically useful only for irrigation. The court points out that if the extreme rule of the common law were enforced, Oklahoma having the same right to insist that there should be no diversion of the stream in Kansas for the purpose of irrigation that Kansas has in respect to Colorado, the result would be that the waters, except for the meagre amount required for domestic purposes, would flow through eastern Colorado and Kansas with comparatively little advantage to either State and both would lose the great benefit which has come from the use of the water for irrigation. Comparing the great meagre detriment to the southwest part of Kansas that, the court decided, has been due to irrigation in Colorado, with the great benefit which has obviously resulted to the various counties in Colorado, the decision is reached that equality of right and equity between the two States forbids any interference with the present withdrawal of water in Colorado for irrigation ends. In one sense, therefore, the decision may be considered a decisive victory for Colorado, but it is unfortunate that the decision could not have been rendered in a more general manner so that the development of the West by irrigation with interstate waters would be placed on a somewhat more substantial basis.

Notes and Comments.

The Assuan Dam in Upper Egypt will be strengthened in an unusual manner, according to the Engineering Supplement of the London "Times." The extremely high temperature in the sun during the summer months causes much expansion of the masonry, and it is considered impossible to bond new masonry into the existing work which, during the past few years, has cooled down to a fairly average temperature so far as its interior is concerned. The strengthening will therefore be attained by the construction of an independent mass of masonry free to contract until it assumes the same temperature as the older mass, when it will be bonded to the latter by cement grout and steel rods previously built into the work. It is stated in the journal mentioned that all theoretical conditions will be complied with by the adoption of this system of construction and the strengthened dam will support 2½ times the quantity of water which the present dam furnishes without increasing the stress upon the masonry or reducing the factor of safety in any respect. The work has already been started and it is expected that it will last about five years.

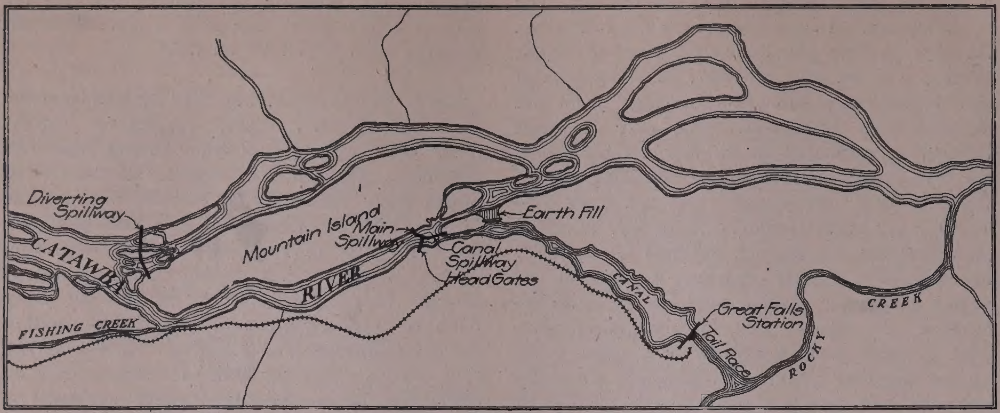
The Brennan Monorail System, which was shown at the meeting of the Royal Society in London on May 8, is one of those startling novelties extremely difficult to estimate at its proper worth from the inadequate details cabled to this country concerning it. If the stories concerning the system are based on facts, it is beyond question a very interesting subject of study. The elementary principle is simplicity in itself, being that of the common gyroscope, which is utilized to keep a car in a vertical position on a single rail, along which it is propelled in the usual manner. Experiments indicate that a gyroscope of large size can be made which will keep a car steady on a single rail even when propelled at an extremely high rate, and in this way various difficulties due to grades and curvature which exist with a two-rail track can be overcome. The stories of the invention which have reached America sound so much like fairy tales or the prospectuses of mining companies that even the inventor will acknowledge it is the part of wisdom to delay any expression of opinion until more complete details are available.

A Municipal Electric Plant with an unusually successful record was established at South Norwalk, Conn., in 1892. Prior to that time indifferent service had been furnished at high rates by a private company, which led the city to construct a 100-h.-p. plant for running less than a hundred street arcs. The work was begun under the direction of Mr. Albert E. Winchester, then central station designer for the original New York Edison Co., who lived in South Norwalk. The success of the public lighting was so great that six years later the plant was enlarged to supply lights to private consumers, and since then the equipment has been enlarged from time to time as the demand for current grew. There are four steam-driven 60-kw. units and a 165-kw. unit using a Diesel oil engine. The operating data of most interest are the following: Average income per kilowatt-hour, 4.48 cents; average cost per kilowatt-hour, including interest and depreciation, 2.76 cents; average profit per kilowatt-hour, 1.72 cents. The cost of street lighting is estimated to be considerably below the rate of $74 charged in the adjoining city of Norwalk while the private rates are from 6 to 10 cents per kilowatt-hour. Under Mr. Winchester's direction, the lighting business is conducted like that of a private company, so that all expenses are met by income, and the good results attained are largely due to his management. This is mentioned because it is a good proof of the fact that when such municipal undertakings are well managed they may reasonably be expected to be both economical and satisfactory.

The Strangling of Railway Enterprise which seemed likely to become fashionable in certain sections recently was comprehensively exemplified in a veto message by the governor of Texas some time ago. There were four little disconnected railways in the eastern part of the State doing nobody much good and unable to give the through service necessary to develop the regions through which they passed. Finally the Atchison directors decided to venture several million dollars on their consolidation and improvement into the Gulf, Colorado & Santa Fe Ry Co., a Texas corporation, an undertaking so unattractive to local capitalists that it was not considered likely to find backing. This purchase was warmly supported by the people of the district traversed and the legislature readily authorized the project, which opened up a section of the State suffering from lack of transportation facilities. The governor has vetoed the project, however, in a message the logic of which the following sentence typifies: "Shall we tolerate a system under which a foreign corporate pirate may consolidate the independent railroad lines of Texas into one vast railroad trust?" To those who are acquainted with the detailed control of transportation companies in Texas by the State Railroad Commission and the legislative opposition to railroad projects not based on public needs, this position assumed by Governor Campbell seems diametrically opposed to the State's best interests.

The Steel Rail War between the mills and the railway companies has at last broken out, although in an entirely unexpected place. The first sign of the conflict was the recent award by the Harriman interest of an order for 157,500 tons of rails made by the open-hearth process to the Tennessee Coal & Iron Co. In addition to being the largest order for steel rails ever placed in this country, the fact that it calls for open-hearth steel is extremely significant. Engineers have been struggling to obtain open-hearth steel for a number of years, while manufacturers have just as strongly opposed giving it to them, contending that Bessemer rails were good enough. Since accurate records of the breakage of rails have been kept in a number of places, the positiveness of the assertion of the good character of Bessemer rails has somewhat abated and preparations are being made for the manufacture of open-hearth rails in many places. Probably this concession to the demands of engineers and railway companies is made with the purpose of withstanding the accompanying demand for more complete working of the metal which goes into rails. It is generally held by railway engineers that a good many rail breakages are due not so much to the quality of the metal as to the fact that the rails do not receive such a thorough working as was formerly the case. The cost of this extra working is high and it would cause a material reduction in the capacity of a mill from that obtained by present processes. Inasmuch as the aim of mills to-day is tonnage, it would seem that they are conceding open-hearth metal for the sake of deferring the date when a more thorough working shall be forced on them.

Chas. H. Haswell, who died on Sunday from the effects of an accident, occupied for a great many years a unique position among American engineers. He was chief engineer of the United States Navy before Queen Victoria mounted the throne of Great Britain, and in a long and busy life he saw the development of civil engineering from an insignificant beginning into a great profession. It is not too much to say that for many years he exercised a strong influence in molding the developments of engineering. As the author of a famous reference book of technical data he placed in the possession of other engineers a great amount of information which was widely used and considered for nearly half a century as standard authority. As was natural in view of the recent great development of the sciences on which engineering is based, toward the close of his life the methods and rules he advocated became antiquated, and a good many young engineers have thought there was something undignified about quoting the famous pocket-book, and for the same reason there probably has arisen a lack of appreciation on the part of these same younger engineers of the great work which Mr. Haswell did. It is necessary to judge most things by the conditions under which they were produced, and if anyone will take the pains to go back fifty years and examine the information available for engineers at that time he will find that Haswell's pocket-book was unquestionably a great and valued aid. It could not express, however, one of the characteristics of the author, his good judgment of engineering possibilities, what is often called the engineer's common sense. This is a faculty which does not depend, except in a minor degree, on scientific information or on a knowledge of engineering literature. It is inborn, and it was this faculty that enabled Mr. Haswell to design the machinery of the "Powhatan," something that American engineers may well be proud of. Amidst all the routine details attached at that time to the office of chief engineer of the Navy, Mr. Haswell personally drew all the plans for the boilers and engines of this very successful vessel. Of course her machinery would be entirely out of place in a modern vessel, but when it was constructed it represented the highest state of the art. It was probably this engineering common sense which enabled Mr. Haswell to be successful in many lines of work. He was connected for a great many years with the municipal works of New York; indeed at the time of his death he was engaged on the improvements of Riker's Island in New York Bay. This wide range of trained judgment, an intimate knowledge of the basic principles on which engineering rests, a great love for his profession and a feeling of high respect for those who contributed to its elevation and development, combined with a deep interest in social affairs to make Mr. Haswell a most enjoyable companion in work or in hours of relaxation. Whenever he was in the Engineers' Club he was surrounded by a group of men whose interest and enjoyment in his conversation was always remarked by guests. Of the men with whom he was thrown in more or less close contact, very few, indeed, of those of half his age or less possessed his extraordinary vitality or took a keener interest in the work and play going on about him. Very few men live to the age of 98 years, which was almost reached by Mr. Haswell, and of the few who do attain such ripe years hardly one is engaged regularly in work down to the time of his death or is active socially. His name will long have an honored place in the roll-call of American engineering, which he did a great deal to establish on its present firm footing in public estimation.



Location of Diverting Spillway, Headworks and Station, Great Falls Development.

THE GREAT FALLS STATION OF THE SOUTHERN POWER CO.

Part I.—Description of the Natural Power and the Hydraulic Features of the Development.

By Curtis A. Mees, Assoc. M. Am. Soc. C. E., in Charge of Design, Southern Power Co., and John H. Roddey, Assoc. A. I. E. E., Assistant in Engineering Department.

There has already appeared in The Engineering Record of July 23 and 30, 1904, a description of the hydro-electric plant of the Catawba Power Co. This property was at that time only partially developed. Subsequently the demand for power so far exceeded the most sanguine expectations of the company that, with the original installation hardly limbered up, the completion of the equipment was undertaken. With the original machinery running continually and taxed with a large overload, the erection of the additional power units was of necessity a slow procedure. While the work was in progress a contract was made whereby the company undertook the municipal lighting for Charlotte, N. C., and it now carries also the major portion of the private lighting. That such contracts might be specially safeguarded against interruption of service there was taken over for operation under lease a 1,500-kw steam plant. The sale of power generated by this plant and disposed of at $20 per horse-power-year entails daily loss, but it is necessarily operated at its full capacity, for as yet the total output of the Catawba Power Co. is quite inadequate to meet the demand. Such conditions existing in a territory so richly endowed with water-power sites suitable for economical development resulted in the organization on June 20, 1905, of the Southern Power Co., which proposes the development of water powers on rivers located principally in lower North Carolina and upper South Carolina, and the transmission and sale of electrical energy thus generated to industrial establishments for power and for municipal and private lighting.

In this company was merged the Catawba Power Co., above mentioned, operating a 10,000-h.-p. hydro-electric plant on the Catawba River, some six miles from Rock Hill, S. C., and also, by subsequent purchase, the plant of the Catawba Electric & Manufacturing Co., whose properties consisted of a mill operated under lease by the Linen Thread Co. of New York and such lands lying on the Catawba River some 13 miles from Charlotte, N. C., as control a portion of the Mountain Island water-power, already partially developed for supply of power for the operation of this mill.

The Southern Power Co. owns or controls in all nine water-power sites in the so-called Piedmont Section, embracing the sand-hill district, extending from the foot of the Blue Ridge mountains to the fall line, a distance averaging probably 120 miles. One capable of development for 12,000 h.-p. lies on the Broad River of the Carolinas equi-distant from Gaffney and Blacksburg, S. C., while another is located on the Wateree River, of which the Catawba River is the principal tributary. This one is capable of development for 20,000 h.-p. All others are on the Catawba River. The aggregate of these powers will amount to 145,000 h.-p., which will be transmitted to cover a territory over 150 miles long and about 100 miles in width.

View of Power Station and Dam during Construction.

The Great Falls. Of these different power sites, the one known as the Great Falls of the Catawba was the best for initial development, and owing to incessant demands for electric power, construction on this was commenced immediately after the accurate surveys of the property had been completed, and with the plans and designs for the plant only roughly outlined. Such conditions necessitated construction by company forces. There was, therefore, purchased with all possible haste a $150,000 contractors' plant, a town was built for employees, and the inaccessibility of the site was overcome by the construction of about 12 miles of standard gauge railroad to connect with existing lines.

The Great Falls of the Catawba consists of a series of falls and shoals having a total head of 176 ft. in a distance of about 8 miles, the development of which will require three separate plants.

The lowest of these necessitates the construction of a dam across the river at a point just below the mouth of Rocky Creek, at which point there is available a drainage area of 4,450 square miles; a development of 60 ft. is here feasible, which head backs water to the elevation of tail water in the middle development. The development of this site is now being prosecuted with all vigor.

The highest development with a drainage area of 3,900 square miles will be effected by the construction of a dam immediately above the mouth of Fishing Creek. This plant will operate under a head of 40 feet, and its tail water elevation will correspond to head water for the middle development.

The middle development with a head of 72 ft. receives the run-off from the drainage area of 4,200 square miles, and is known as the Great Falls Station, the subject of this description.

From observations made under various auspices it has been deduced that whereas the minimum flow of the rivers in this particular locality averages about ½ cu. ft. per second per square mile of drainage area and for eight months in the year about ¾ cu. ft. may be depended upon, the flood volume against which precaution must be taken in design is somewhat below 50 cu. ft. per second per square mile, such flood-water flow being an exceedingly high one, and, it is thought, the greatest on record with the U. S. Geological Survey.

This development consists essentially of a low spillway dam at the head of Mountain Island to deflect the water into the western channel. Flowing through this channel nearly to the foot of the island, it is then forced through the head-gates of the canal by another spillway dam. An extension of this dam serves as an overflow weir between the canal and the river. From this point the stream is carried by a canal through a natural valley about 1¼ miles to the power-house and retaining bulkhead built across the valley, while below the power-house the tailrace carries off the spent waters ¼ mile to Rocky Creek, in which channel it is again carried to the river bed.

Canal Head Works.—The deflecting dam at the head of Mountain Island is an ogee section overflow dam only 7 to 8 ft. high, the fall utilized for this development occurring almost wholly in the western channel, and in the dip of the valley through which the canal is carried to Rocky Creek.

The main spillway at the head-gate works, 438.85 ft. long on the crest line with an average height of about 30 ft., has a batter of 1 : 10 on the upstream face and an ogee downstream face. The corresponding width at the base of the section is about 41 ft. This spillway in connection with the diverting spillway at the head of Mountain Island is designed to carry safely a flood-overflow corresponding to 50 cu. ft. per second per square mile of drainage area, which volume of flood water will cause overtopping of the crest of the dam to a depth of 14½ ft.

The curve on the downstream face was determined by plotting the parabolic curve for the average velocity of the film of overflowing water increased by an assumed initial velocity of 8 miles per hour, and so fitting the masonry to this curve as to intercept the nappe, breaking the velocity near the top and thus insuring contact of the sheet of water on the entire downstream face. The weight of masonry was assumed to be 125 lb. per cubic foot. An upward pressure equal to two-thirds of the head at the heel of the section and decreasing to zero at the toe was assumed to exist, and there was also considered to offset this pressure the weight of the overflowing sheet of water tending to increase the stability of the dam. Under these assumptions the section shows a safety factor of two for the most severe conditions, with increasing stability as the conditions approach the normal stage.

The spillway in the canal, similarly designed, and 521.2 ft. long on the crest, averages about 36 ft. in height, corresponding to which height the base has a width of about 37 ft. 9 in. The crest of this weir is 1 ft. higher than that of the main spillway and its length is such that, with the worst conditions of flood that may be predicted, it will when overtopped to a depth of 8 ft., carry off all the water that the canal headgates will vent.

These spillways, the headgate masonry and all heavy bulkheads were built of concrete masonry, in which are imbedded displacement stones as large as could be handled by the derricks. All masonry is founded on bed granite of a close and uniform texture. Sectional forms were used to the greatest practicable height, the upper curve being then finished by hand and template.

The concrete was mixed largely in the proportions of one part of Edison Portland cement to two parts of sharp creek sand obtained on the building site and five parts of crushed granite, the run of the crusher having been used throughout.

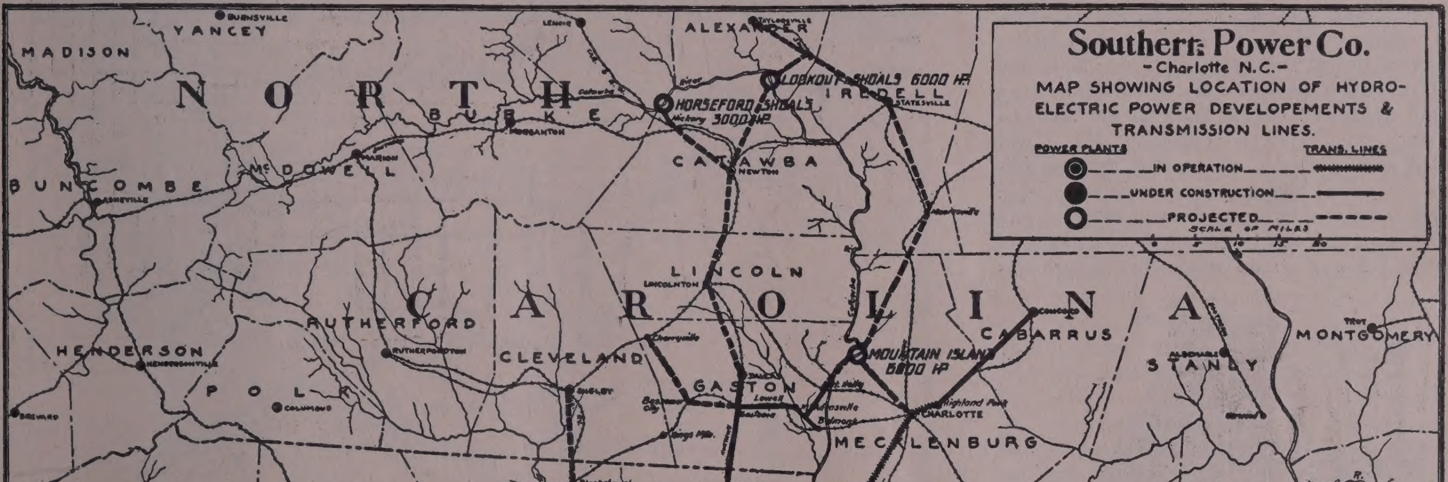
The headgate masonry supports a set of coarse racks and has in it ten ways 16 ft. wide and 18½ ft. high with full-centered arch tops. These gate openings are separated by piers 5 ft. in width. This section, averaging about 45 ft. in height, is 8 ft. wide on top, and the downstream side is battered 3 on 1. The piers are extended on the downstream side to form buttresses, which are 5 ft. wide, 3 ft. long on a level with the top of the main wall, and battered 2 on 1. Piers are also carried out on the upstream side for the support of the rack structure. These are 3½ ft. long on top, this being 6 ft. below the top of the main wall, and are battered 12 on 5, giving for the section a total width at the base of the gate opening of about 47 feet.

The gate frames secured into this masonry are built of standard structural steel shapes. They are of the same dimensions as those used for the gates of the turbine intake flumes, and it was contemplated using the turbine headgates in these frames for construction purposes. Temporary gates were, however, later built of timber for this purpose.

In the event of placing gates in these frames it might become necessary to relieve the pressure upon them before raising, and for that purpose a by-pass has been built through this masonry at the shore end. This by-pass, though hardly adequate, does, at least, present possibilities of usefulness. The gate is of timber and is operated by a style "H. H." S. Morgan Smith gate hoist.

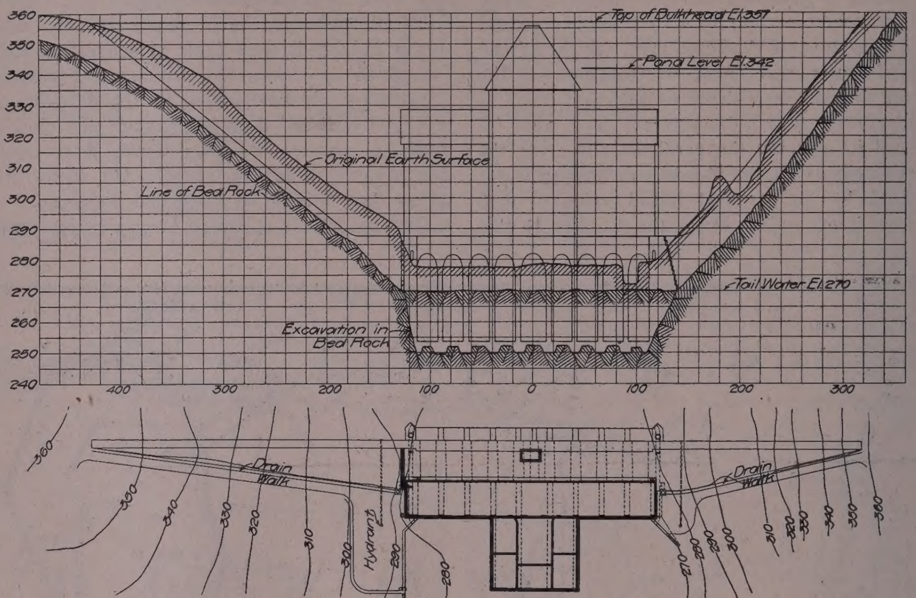
For the purpose of draining the low point immediately below these gates, a 4x5-ft. Coffin sluice gate was built into the bulkhead, discharging below the spillway.

The racks protecting these water-ways are coarse, being built up of ⅜-in. gridbars, 5 in. deep, spaced 3 in. center to center and separated by cast-iron spacers of such design as to prevent twisting of the bars under shock. These gridbars are supported by a structural steel frame, which in turn is supported by steel members built

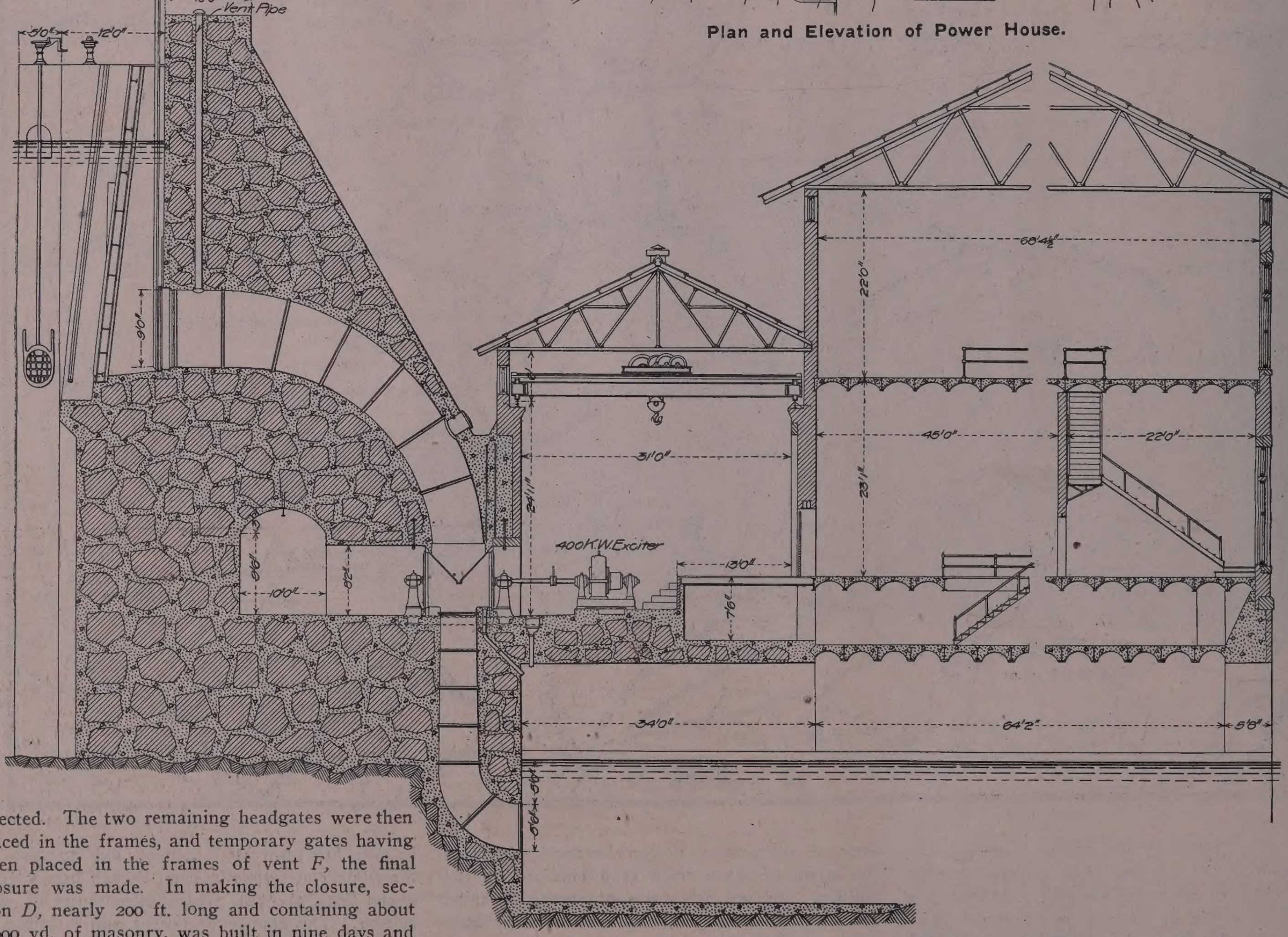


into the rack piers. This entire rack structure was designed of such strength as to withstand any pressures that might occur with a full head of water against a completely clogged rack. The racks were set on a batter of 12 on 5, so that logs and debris that might lodge against them should be forced to the top, whence they might be piked to a sluiceway 3 ft. deep and 8 ft. wide left in the spillway section for that purpose. There have been left in this sluiceway grooves for the accommodation of stop-planks should such economy of water become necessary.

Construction of Headworks and Canal.—The method employed in the prosecution of this work was, in general, as follows: Cofferdam No. 1 was built deflecting all the water to the deeper channel. The block of masonry marked *A* was then built. These cofferdams consisted of log cribs filled with stone and sheathed top and sides. The building of blocks *B* and *C* was then undertaken, whereupon cofferdam No. 2 was built, and when completed cofferdam No. 3 was built. Then all the headgates, except those in the last two frames, were closed, and cofferdam No. 1 was opened and the water was vented through sections *E* and *F*. Temporary gates were then placed in the vent, *E*, but a flood at this time tore out the gate pier, and necessitated the building of cofferdam No. 4, within which this closure was effected. The two remaining headgates were then placed in the frames, and temporary gates having been placed in the frames of vent *F*, the final closure was made. In making the closure, section *D*, nearly 200 ft. long and containing about 6,000 yd. of masonry, was built in nine days and nights.



Plan and Elevation of Power House.



Cross-Section of Bulkhead, Intake, Turbine and Transformer Rooms.

For carrying the water from this point to the power-house it was necessary to excavate but little material to secure a hydraulic grade line from the bottom of the canal gates to a point 4½ ft. lower at the power-house.

Such excavation as was necessary to secure a cross-section with a base of 100 ft. and side slopes in rock of 2 on 1 and in earth of 1 on 2 amounted to but 195,000 cu. yd., for a total length of 7,250 ft., and all of this material was quite necessary for filling in a gap existing between the valley and the river. This excavation was originally contracted for, but was later undertaken with company forces.

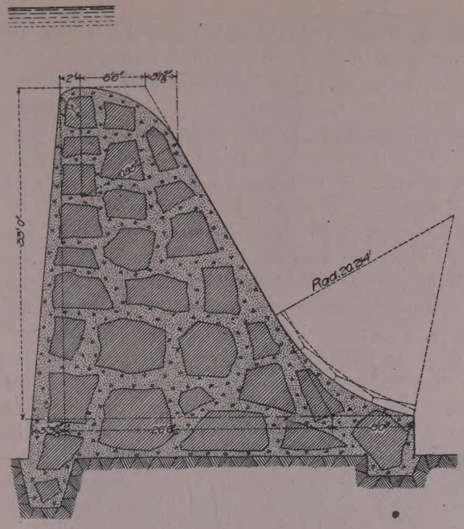
The site of the fill was prepared by clearing off all vegetable matter along a strip 100 ft. wide, and on this strip a puddle of selected material was placed.

Station Intakes. At the lower end of the canal the water is impounded by a concrete retaining wall or bulkhead having a width on top of 8 ft., a vertical upstream face and a downstream face battered 1.75 on 1, the height in the center of the valley being about 90 ft. This section is largely increased in that portion opposite the power-house, for here there are built through the bulkhead the intake flumes for the turbines, the cases of which are also built into this masonry, whereas the power-house is built immediately below the bulkhead, forming virtually a part of it.

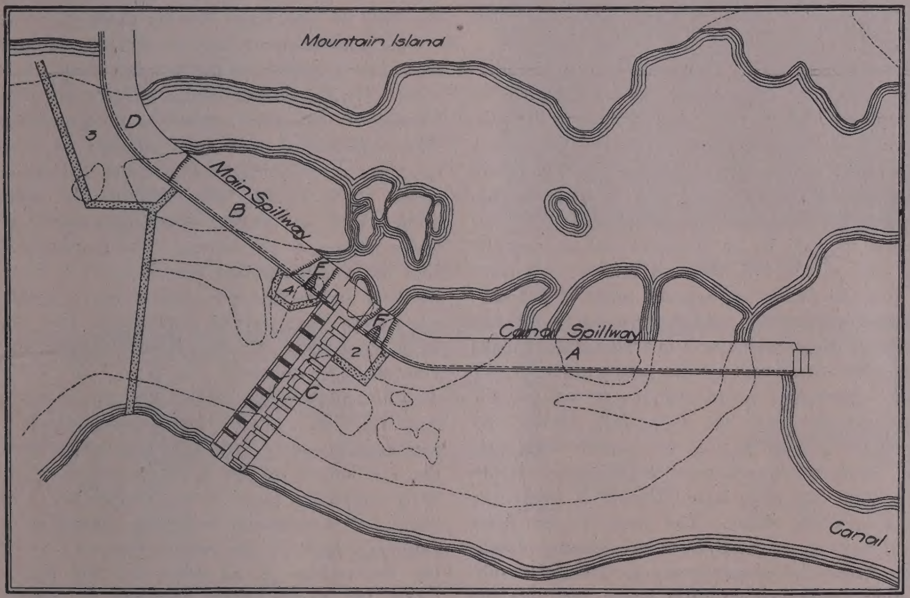
Through this masonry, carrying past either end of the power-house, there have also been constructed two trashways for bypassing leaves and small debris from the racks. These are 48 in. in diameter, built of riveted steel pipe and closed by Coffin sluice valves. Into these, by a manhole and check valve, there is also carried storm water off the side slope of the valley.

Before the water passes the headgate of the turbine intake it is again strained through a set of racks similarly constructed to those at the head of the canal, except that these are finer, the grid-bars consisting of ¼-in. bars 4 in. deep, spaced 1½ in. center to center. Provision has been made for the attachment of a power-operated rack-cleaning device, which will have to be installed a few years hence when leaves once commence clogging the racks.

After passing these racks the water is controlled in its passage to the turbines by structural steel gates. Eight of these for the generating units are built of 6-in. I-beams, and are covered with ⅜-in. steel plate on the outer side. On the inner side they have bronze running strips at the sides and opposite the supporting beams in the gate frame, while machined steel bearing plates at top and bottom insure tightness when the gates are closed. Each of these gates is provided with two 9x14-in. filling gates for reducing the pressure before raising, these being hand-operated from the top of the bulkhead. The gates are suspended upon steel stems, each built up of an 8-in. 18-lb. I-beam, and a 9-in. 20-lb. channel, to the latter of which is secured the pinion rack engaging with the gate-hoist.



Canal Spillway Section.



Location of Cofferdams Used in Constructing Headworks.

The gates are operated by a multiple spur and worm gear off a shaft actuated by a motor from a point in its center. The motor is stationed in a small house on top of the bulkhead, the leads for it being carried in vitrified conduit to a switch-box in the tunnel and thence to the switchboard. Speaking-tubes are carried from this house and also from various points in the transformer house to the operator's desk in the power-house. On account of the great initial torque required, a direct-current compound-wound motor with a weak shunt field, operating from the exciter circuit at 250 volts, was selected for this power. This is practicable since the exciter plant is of a capacity largely in excess of that required for the mere excitation of the generators. By the use of pin clutches it is made feasible to operate any or all gates at one time. The clutches must, of course, be thrown in while the shaft is at rest. Provision has also been made for operating any of the gates by hand.

The two gates for the exciter intakes are similar to those just described, except that they are framed out of 4-in. I-beams, the stems being composed of a 6-in. 12¼-lb. I-beam and a 9-in. 13¼-lb. channel, and but one 9x12-in. filling-gate is provided. They are raised by hand-operated mechanism. All these gates slide in heavy frames built of structural steel shapes anchored into the masonry of the bulkhead wall. Directly behind the gate frames, but not rigidly attached to them, commence the intake flumes or feeder pipes for the water wheels. These are made of ⅜-in. boiler plate stiffened by 6x3½x⅜-in. angles riveted around it. These feeders taper down from the headgates, where they are 16 ft. wide by 18½ ft. high with semicircular ends, to 16 ft. in diameter at the mouthpiece of the turbine case.

View Along Canal Spillway toward Headworks.

Turbines.—There are ten units, each consisting of a pair of horizontal twin turbines with top inlet and center discharge. Eight of these were required to furnish 5,200 h.-p. at 225 r. p. m. under a head of 72 ft.

Of these units two were furnished by the Holyoke Machine Co., Worcester, Mass. Each is a pair of 48-in. wheels enclosed in a cast-iron wheel case mounted in a turbine case of 7/16-in. boiler plate riveted to cast-iron heads. The latter are stiffened against shocks by four 2½-in. Norway iron rods extending from the front to the rear head.

In the feeder pipe and over the center of the turbine is a manhole, just inside which is an eyebolt for the suspenson of blocks for handling turbine parts. Pressure and air vent pipes 12 in. in diameter run up through the bulkhead.

The draft tubes are 8 ft. 10 in. in diameter at the wheel case, being flared at the bottom to a width of 18 ft., the ends being semicircular and of 4 ft. 5 in. radius. The top of the mouth is sprung to form an arch 2 in. high to prevent any possible collapse of the metal away from the masonry. These tubes are fabricated from 7/16-in. plate and are stiffened in the same manner as the intake flumes.

The plates of the upper 12 ft. of the draft tube from the saddle down are butt-jointed and strap covered on the outside with countersunk rivets on the inside. Below these plates the joints are telescopic, with the lap in the direction of the flow of water. In the heads of the turbine case are removable crown plates of such size as to permit removal of any part of the work inside the flumes.

Should it become necessary, the turbine cases may be drained by valves operated from the power-house. Check-valves, for removal of any water seeping into the power-house, are provided before each unit in a sump, which extends the entire length and in front of all the wheel cases.

Vacuum gauges are provided for all draft tubes. The draft head in these wheels is 22 ft., and the draft tubes are submerged 5 ft., which depth was deemed necessary to permit drawing off the pond on the lower development.

The runners of the wheels are of bronze and mounted on a shaft 30½ ft. long made of forged nickel steel; it is 9, 10 and 11 in. in diameter, with a flange coupling keyed to it for connection to the generators. This shaft is supported on the outside of the turbine case by ring-oiling ball and socket bearings, the one in the power-house being made to harmonize in appearance with the bearings of the generators.

A special feature of this plant is the construction of a tunnel extending the length of the power-house through the bulkhead and just back of the turbine cases. By this method of construction the usual outboard water-bearing is replaced by an oil bearing which may be inspected at will, and the removal of water-wheel parts is also greatly facilitated. This tunnel is 10 ft. in width and has a segmental arch top, in which is anchored an I-beam trolley for carrying material to and from the power-house, into which the tunnel opens. Ventilation is here provided by three 12-in. air flues to the top of the bulkhead. The water-wheel shaft extends into this tunnel through a cast-iron head similar to that in the power-house.

The outer bearings are ring-oiling ball and socket bearings of the propeller type. The pedestal boxes are rigidly connected to the head being designed to take up the end thrust of the water-wheels. The flow of water to these wheels is regulated by cylinder gates. All racks and pinions for the gate work are placed on the outside of the turbine case. Hand regulation is provided for these units separate from that of the governors.

The guaranteed efficiency of each of these units is determined by a curve passing through the following points:

Discharge	Full	⅞	¾	⅝	½
Efficiency, per cent.	81	82	81	74	68

Six of the larger units were built by the Allis-Chalmers Co., of Milwaukee, and having been designed to meet the same conditions as the Holyoke turbines, the hydraulic construction, except as to water-wheel detail, is in many respects similar. They are set in a turbine case of 7/16-in. plate, 15 ft. in diameter and 19 ft. long. In this case the cast-iron heads are stayed across the wheel case. The feeder pipe is 18½x16 ft. at the intake gates and tapers to 15 ft. in diameter at the mouth-piece of the turbine case.

The draft tubes are 11 ft. in diameter at the base of the wheel case, and flare to 18 ft. 3 in. by 11 ft. 2 in. at the lower end. Two of these units are provided with bronze runners 53 in. in diameter and four have runners of special cast iron the latter being guaranteed against failure or undue wear for a period of five years. The gates are of the register type, being nearly balanced, with, however, a tendency to close.

The shaft is of forged steel 9, 11 and 13 in. in diameter, and has a flange coupling forged to its end for the generator connection. The guaranteed efficiency curve passes through the following point:

Discharge	Full	⅞	¾	⅝	½	¼
Efficiency, per cent.	80	81	82	80	78	60

The two exciter units purchased from the Allis-Chalmers Co. are similarly built. These units were required to furnish 700 h.-p. at 450 r. p. m. under 72 ft. head.

At the intake the feeder pipes are 9 ft. high with semicircular ends of 3-ft. radius, and taper to a diameter of 6 ft. at the mouth-piece of the case. Feeders are equipped with manholes and 8-in. vent pipes. Runners are 24½ in. in diameter, the shaft 5½ in. in diameter, and the draft head is 21 ft. 2 in. The draft tubes are 5 ft. 6 in. in diameter at the case and flare to a width of 9 ft. 10 in. with semicircular ends of 2 ft. 9 in. radius.

For facility in erection the water-wheels were mounted on a long, heavy structure of I-beams to span the openings left in the masonry for the draft tubes extending from the arches of power-house substructure to the masonry built up outside the draft tube clearances. It was proposed setting these with the cradles in place, rigidly suspending from them the draft tubes, and then filling in around them with concrete. However, owing to delayed deliveries of the cradles, the draft tubes were loosely suspended from temporary beams braced to position and concreted in, the connection with the cradle fitting very well.

Regulation of this plant is effected by an installation of governors manufactured by the Lombard Governor Co., of Ashland, Mass. The generators are governed in pairs and for each pair a type N governor is provided, while both exciters are controlled by one type P governor. There are provided for this installation four 4x6-in. triplex pumps operated by a belt from the water wheel shafts. All pressure and vacuum tanks are placed in the bearing tunnel and the entire system is interconnected. The type N governors developing 31,000 ft.-lb. are guaranteed to completely open or close the water wheel gates in 1½ sec., while the type P governor will close exciter gates in 4 sec., developing 6,700 ft.-lb. The larger governors are electrically controlled from the switchboard.

Power-House.—The generator turbines discharge into the tail-race between piers, which being spanned by full centered arches, form the substructure of the power-house. These piers are 5 ft. in width and 25 ft. on centers, except where both exciter turbines discharge into the same bay, the piers forming this one being 30 ft. on centers and bridged by an elliptical arch, giving the same rise as the full centered arches. All piers and also the facing on exposed parts of the substructure were built out of very finely finished dimension stone, which was quarried out of locks built in the early part of the last century by the State Government in an attempt at making the river navigable past the falls and shoals. By this means and by paving the bottom with concrete, these tail-flumes were made quite smooth and present but little impediment to a rapid discharge of spent water. The piers for the three central bays are carried in a like manner downstream from the power-house to form the substructure for the transformer house, but here the span between piers is not bridged by an arch, except just at the lower end, where these arches carry the outside wall and were used largely for the sake of maintaining a uniformity in the external appearance of the structure.

The power-house is a building 250 ft. long and 37 ft. wide; the transformer house extending from this is practically a three-storied building, 71 ft. in width and 85 ft. long. These buildings, of fire-proof construction, are faced on the outside with red pressed brick and on the inside with a gray sandlime brick, the body of which is granite dust. Weepers were built just back of the brick walls on the bulkhead side of the power-house, drainage from these leading to the sump in the power-house. The roof covering consists of Bonanza tile resting directly on steel purlins supported by steel trusses. These tiles lay up 24x48 in., and are built of concrete reinforced by expanded metal and made interlocking. They have a water-proofing burned into the exposed surface, showing a pleasing red. The roof of the transformer house was designed with a wide overhang for the protection of the line openings. Proper ventilation was, it is hoped, effectually provided for by the use of very large windows with casement side sash, which may be widely opened. Windows were also placed above the crane track on the upstream side of the house. These windows are hinged on top, the entire gang being operated from two power sash-lifting devices at opposite ends of the power-house. By this means it is possible to close them readily in case of sudden shower when rain might blow in on the electrical machinery. Two 20-in. ventilators were placed in the roof over each bay, and a 48-in. slat ventilator was built into each end of the house. The slats in these are built into separate frames, so that they may be readily removed, and fans attached to the stationary frame. In both ends of the house are placed Kinnear steel rolling doors with a clear opening of 16x11½ ft.

A conduit for the accommodation of wires and pipe extends along the downstream side of the power-house, the top forming a platform 3 ft. 9 in. above the floor line. This platform widens on a circular arch in the center of the house, opposite the exciter, forming a dais for the mounting of switchboard and instrument posts. A hand-operated traveling crane runs from one end to the other of the power-house. This has a capacity of 25 tons, and is equipped with a drum on which is wound the plow steel hoisting rope. The girders are built of reinforced I-beams, and on the lower flange of one of these operates a 5-ton auxiliary trolley with triplex block. In the tunnel a 5-ton trolley is suspended from the crown of the arch on an I-beam track for the handling of wheel and bearing parts.

The transformer house, as already stated, is a two-storied structure, the conduit floor or basement of which is practically on a level with the bottom of the cable conduit in the power-house. The skeleton of this floor consists of I-beams spanning the opening between piers, the space between these beams being spanned by concrete arches with a concrete covering protecting the lower flanges of the beams. The piers were carried full width through this floor. The floors of the first and second floor are similarly constructed, except that curved corrugated steel sheets were supported on the lower flanges of the I-beams, and on these was placed the concrete. The first floor is on a level with the switchboard platform. It is divided into rooms for housing transformers over both side bays and extending the full length of the house, while that portion lying above the piers of the central bay forms a room for low-tension switching apparatus. Immediately back of the switch-room and overlooking the tailrace is an office for the operators. From the power-house, entrance is gained to those rooms in which the transformers are placed through arches protected by rolling steel fire doors with fusible links. A similar door divides these rooms into two separate compartments, so that any one bank of transformers will be automatically isolated from the others in case of fire. The second floor has no partitions in it whatever, forming thus a room of such size as to contain all the high-tension apparatus with a generous allowance for clearance between leads. All apparatus is taken up through trap doors located above the tracks for the transformer transfer carriage, thus making their handling a simple matter. A 36-in. ventilator in the roof will insure against excessive temperatures in this room.

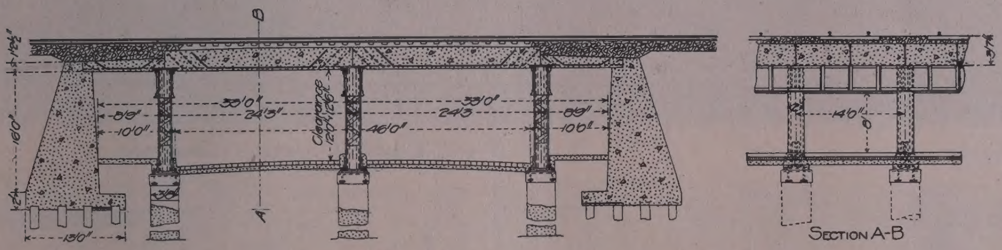
A Large New Ore Dock has recently been completed at Marquette, Mich., for the Duluth, South Shore & Atlantic Ry. It is a timber structure 1,200 ft. long with 200 ore pockets and has a storage capacity of 50,000 tons. The structure is 51 ft. wide outside of partition posts and the height from the water level to the top deck is 71 ft. The hinge holes are 40 ft. above the water and the spouts are 32 ft. long, dropping to an angle of 45°. The dock was built in three decks, the timber being hoisted with steam-operated traveling stiff-leg derricks, and the following amount of material was used in its construction: Timber and plank, 7,000,000 ft. board measure; piling, 150,000 lin. ft.; cast and wrought iron, 225 tons; spouts and their fixtures, 550 tons; rock filling, bulkheads, 1,000 cu. yd.; steel plate girder bridges (243 lin. ft.), 150 tons, and concrete masonry, abutments, piers and retaining walls, 1,700 cu. yd.

Special Bridge Structures for the Track Elevation of the Chicago, Burlington & Quincy Ry. in Chicago.

The Chicago, Burlington & Quincy Ry. is erecting, in connection with the track elevation work which it is carrying on in Chicago, a number of street subway bridges having reinforced-concrete deck-girder floor slabs, built in sections at a distance from the site and afterward set in place. The ultimate track elevation plans of this railroad in Chicago contemplate raising the main line tracks from a point near the western limits of the city to the terminal passenger station at Canal and Adams Sts. in the central business district, covering a distance of 6 miles. Practically all of the yard and switch tracks are also included in the improvements, so when the elevation work is completed all grade crossings with city streets will be eliminated. This track elevation work was started several years ago and has been completed for some time from a point near the western boundary of the city to California Ave., three miles from the terminal at Canal and Adams Sts. Work was started in 1905 on the 2¼-mile portion of the remaining section, from Canal St. to Western Ave., and it is probable the closing section from Western Ave. to California Ave., ¾-mile in length, will be placed under construction soon after the present work is completed.

Before the elevation work was started there were five main running tracks from Canal St. to Western Ave., and four from the latter to beyond the western city limits. A sixth main track was laid from Canal St. to Western Ave. in advance of the elevation work, to facilitate the latter and to provide more sufficient facilities for handling the large volume of traffic that is carried over this section of the line.

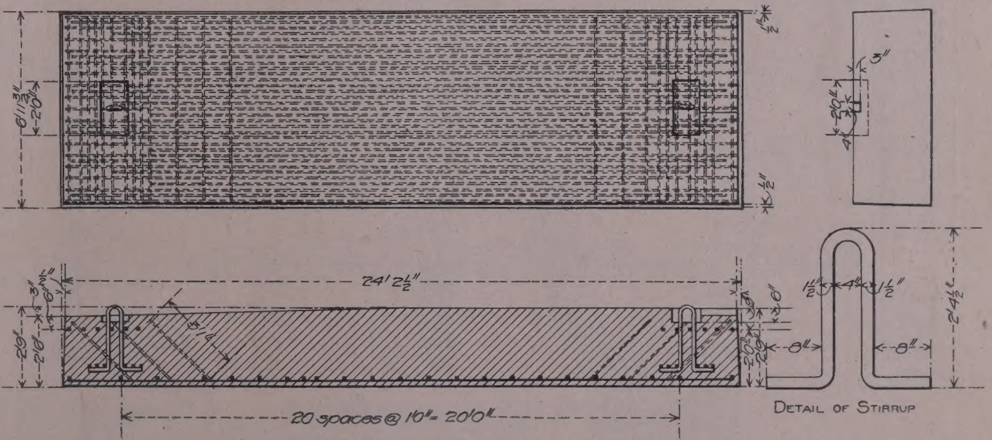
Crane Loading Slabs.



Section of a Street Subway Span.

About 6,000 ft. of the work now under way remains to be finished during this season. In this distance the right-of-way abuts on one side against a city street and on the other side against the right-of-way of the Chicago & Northwestern Ry. The two main line tracks of that railroad are also being raised at the same time, making at all places an eight-track elevation and at places where sidings or yards occur one of considerably greater width. A reinforced-concrete retaining wall along the edge of the right-of-way on the street side holds back from the street the fill on which the elevation is made, and a concrete retaining wall on the opposite side of the elevation separates the latter from the almost continuous row of factory and tenement buildings along that side. The reinforced-concrete retaining wall along the street was described recently in a paper before the Western Society of Engineers by Mr. L. J. Hotchkiss, which paper was reprinted in The Engineering Record for March 9, 1907.

Nine city streets are crossed by the 6,000 ft. of elevation that is now in progress. The tracks are carried over the subways for these streets on four-span reinforced-concrete solid-floor deck-girder bridges resting on abutments along the side of the street and on three transverse rows of steel columns carrying steel box-girders. The roadways have a uniform width of 46 ft. from curb to curb, with a 10-ft. walk on each side, making the total width of the subways 66 ft. One of the transverse rows of columns is along the center line of the roadway, and the other two rows are just back of the curb along each side of the roadway. The bridges thus have two spans over the roadway and one over each side walk.



Details of a Street Span Slab.

The concrete girder slabs over the roadway span from the center line of one row of columns to that of the next and are 24 ft. 3 in. long, 33 in. thick and 7 ft. wide. The girders over the sidewalks span from the outer rows of columns to the abutments. They are 10 ft. 9 in. long, 17 in. thick and of the same width as the roadway slabs, so that two rows of slabs are required for each track carried by the bridge. In some cases where the tracks are 12 ft. on centers the slabs are accordingly made 6 ft. in width.

The details of the reinforcement of the 7-ft. slabs are shown in an accompanying illustration, Johnson corrugated bars being used for reinforcement. The slabs for the long spans contain approximately 16.75 cu. yd. of concrete and weigh on the average 36¾ tons. The slabs spanning the sidewalk contains 3.65 cu. yd. of concrete and weigh 7.8 tons each. In designing, the concrete was assumed to weigh 150 lb. per cubic foot and on this assumption the slabs would weigh 35 tons. When some of the slabs were weighed it was found, however, that the concrete actually weighed 160 to 162 lb. to the cubic foot. As the slabs were all built in a yard about five miles from the work and were afterward moved to the site and set in place, they had to be designed so they could be picked up and moved about readily. At the same time, they necessarily had to embody, when in place, sufficient strength to carry traffic with a proper factor of safety. They were accordingly designed to meet both these requirements.

The slabs were built along both sides of a switch track in one of the yards of the railroad company near the western city limits. A fill of locomotive cinders that had been in place on a clay soil for some time at this site offered a particularly good foundation for the forms in which the slabs were cast. Each slab was built in a separate form that was illustrated in the article by Mr. Hotchkiss, to which reference has already been made. The foundation was first leveled off and then well tamped. The forms for the large slabs were placed in a row on each side of the track with their longitudinal axes at right angles to the latter; those for the sidewalk slabs were placed in two rows on each side of the track. On the foundation thus prepared were placed 4x12-in. plank, in 8-ft. lengths, which were spaced 3 ft. apart on centers transversely with the form. These plank were embedded in the cinders until their tops were flush with the surface and were brought level by using a straight-edge. Three 12x14-in. timbers were set on these plank, lengthwise of the forms and 2.5 ft. apart on centers. After these timbers had been shimmed perfectly level with shingles, a tight floor of 2-in. dressed and matched plank was laid on them to make the bottom of the form. The sides and ends of each form were also built of 2-in. dressed and matched plank with 3-in. studding. They were built and braced so they could be removed readily and used again in making another slab after the concrete had set.

The concrete was made in a mixing plant arranged the same as those which have been used in building the retaining walls and abutments for the track elevation work. A mixer was mounted on one end of a flat car so it could dump into a hopper having its bottom at about the level of the floor of the car. A string of gondola cars filled with gravel was placed back of this mixer car, with a hopper mounted over the front end of the forward car of this string. The gravel was hauled to this hopper in wheelbarrows running on plank runways laid along the top of each side of the cars. The hopper discharged into 1-yd. steel dump cars on standard-gauge four-wheel trucks. A track was laid from the hopper up an incline to a platform over the mixer on the flat car, and the dump cars were hauled up this incline by a cable on a drum on the hoisting engines. The gravel was discharged from the dump cars into a charging hopper over the mixer. The hopper into which the mixer discharged was arranged with an apron at the bottom which could be turned so the concrete would be diverted to either side of the track. A chute leading from this apron was arranged with two openings in the bottom so concrete could be placed in either end of the forms for the large slabs or in either of the two rows of small slab forms. With this arrangement 7 to 8 of the large slabs or 12 of the small ones could be made each day.

The concrete in part of the slabs was made in the proportions of 1 part cement, 2 parts sand and 4 parts crushed limestone which would pass a 1½-in. ring. The greater portion of slabs were made, however, of concrete consisting of 1 part cement to 4 parts pit-run gravel, from which all pieces exceeding in size those which would pass a 2-in. ring had been removed. After the slabs were cast they were thoroughly wet every evening for two weeks. The sides and ends of the forms were left in place 3 to 10 days, depending on the weather. The slabs were not removed from the position in which they were built for at least 90 days after being cast.

The great weight of the slabs necessitated some method of handling them which would insure against their injury as well as against accident to the men engaged in the work. A 75-ton Industrial locomotive turntable crane with a capacity of lifting 40 tons at a 30-ft. radius has been used throughout in moving the slabs. This crane is equipped with a specially designed toggle frame, the details of which are shown in an accompanying illustration. The toggle frame consists of two 12-in. channels, 22 ft. long, which are riveted together back to back with top and bottom plates and are spaced apart so two 5x1-13/16-in. eye-bars with fillers can be placed between them at each end. These two pairs of eye-bars are attached to a 4 7/16-in. hanger pin carried at each end of the pair of channels. The four eye-bars come together over the center of the frame where they are all attached through a 4½-in. hanger pin to a pair of hanger bars carrying a 3-in. pin by which the frame is suspended on a hook carried by the boom of the crane.

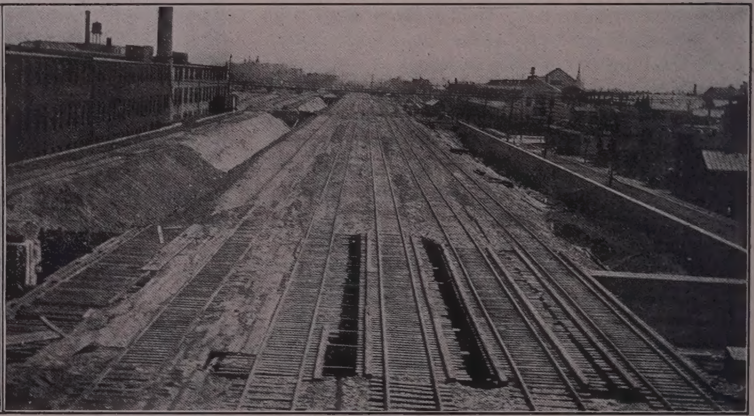
Two methods for attaching this frame to the slabs have been employed. The first was to make a hole toward each end of the slab on the longitudinal center line of the latter by placing a piece of gas pipe vertically in the forms. Two eye-bolts, one suspended from each end of the toggle frame, were then passed through the two holes in the slab and were each attached to a pair of channels placed transversely under the ends of the slab. The slabs could be handled safely enough in this manner, but the objection to the method lay in the fact that the slabs had to be jacked up in order that the channels could be placed under their ends and so the bolts on the lower end of the eye-bars could be placed. This raising disturbed the foundation more or less, so the latter had to be put in condition again after each slab had been moved.

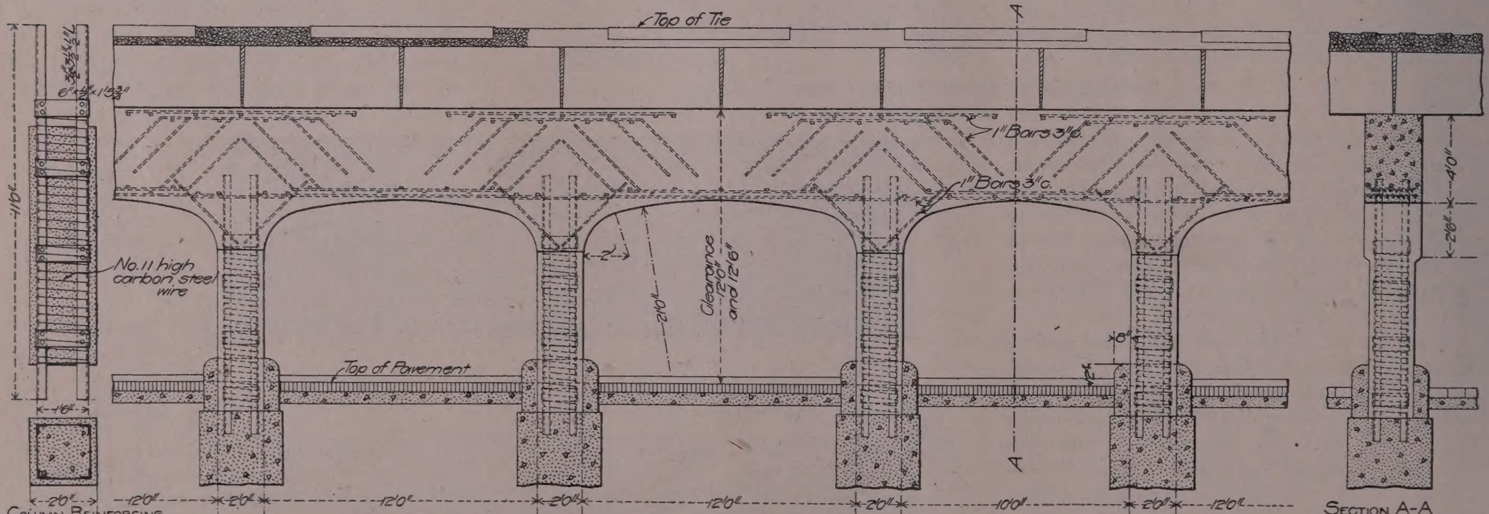
The second method, and the one that is employed now, was to embed an iron stirrup toward each end of each slab and on the longitudinal center line of the latter, the part of the stirrups which projects forming a U-bolt. The method of embedding these stirrups and of reinforcing the slab so the stirrups would not damage the concrete is shown in the detail of one of the large slabs. In handling slabs containing these U-bolt stirrups a hanger bar is suspended from the pin in each end of the pair of channels of the toggle frame; this hanger bar carries two side hanger bars, the latter carrying in turn at their lower ends a bolt which engages the U-bolt in the slab. These engaging bolts are keyed in position so they cannot be displaced. With this arrangement the toggle frame can be quickly and easily attached to the slabs, and no trouble has been experienced with the method of connection.

The locomotive crane picked the slabs up from the forms in which the latter were cast, and placed them on flat cars on which they were hauled to a storage space. The small slabs were piled four high and the large ones three high, in a single row along each side of the track which served the storage space, timber blocks being placed between the slabs to protect the U-bolts. The slabs were not piled any higher owing to the inadequacy of the foundation. As it was only one slab out of the lot of 428 that have been made became center-bound, due to the settling of the foundation, and was cracked across the top.

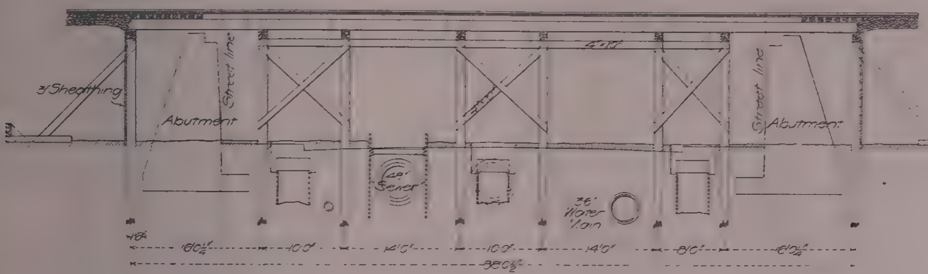
The slabs were all made late last summer and early in the fall. The preliminary work for the portion of the track elevation embracing the bridges in which the slabs are being used was started in 1905, and is just approaching completion, the placing of the slabs being the last of the construction preceding the final laying of track. The first work in connection with the track elevation was to lay the sixth main running track.

Elevation Work in Progress.

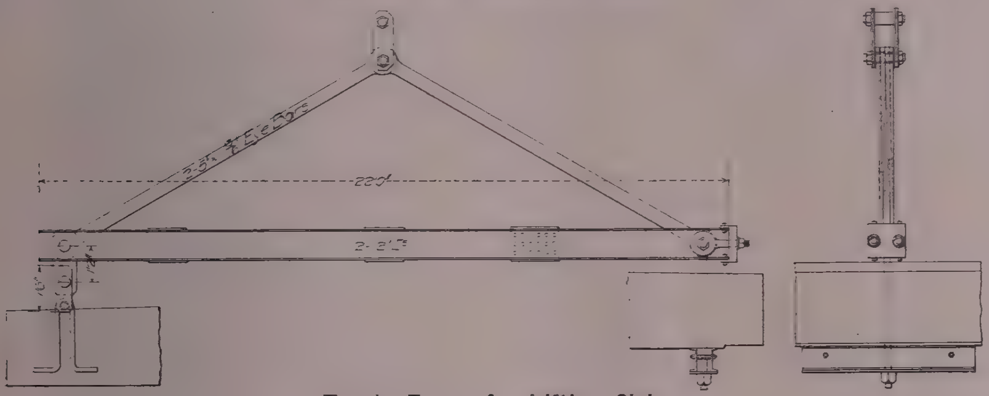

Six-Track Elevation Nearly Completed.



Reinforced Concrete Columns and Girders to be Used in 1908.



Elevation of Temporary Bridge.



Toggle Frame for Lifting Slabs.

The footings for the abutments of the bridges at the street crossings were then brought up to the existing track level without changing the tracks. The outside main track was next replaced by a temporary pile trestle carrying a construction track at about the level at which the tracks on the elevation were to be placed. Filling material was brought in on this trestle in side dump gondola cars or flat cars, and was dumped from the trestle until the fill was brought to grade. The fifth main line track was then abandoned and a track laid on the fill, the position of the fifth track being occupied by a construction track on a trestle. This order of placing a track on the completed fill before throwing out of service one of the main tracks at the original level was followed as nearly as feasible, so that four main tracks were available for service except during occasional periods of a few hours.

Locomotive Crane Carrying Toggle Frame, in Position to Set Slabs.

The temporary pile trestles were continued across the site of the street subways on temporary bridge structures arranged specially to facilitate the construction of the permanent bridges. An elevation of one of these temporary bridges is shown in an accompanying illustration. A pile bent was first driven just back of the site of the bridge abutment on one side of the street, and a tight timber bulkhead was erected against this bent, the latter being anchored back under the site of the fill. Three pairs of pile bents were then driven across the street, leaving two roadways under the track. A bent and bulkhead the same as the first were next placed in the rear of the other abutment, after which the track was torn up back to the next street crossing and the temporary trestle for filling was built.

The bulkheads back of the abutments permitted the fill to be brought up to the latter without interfering with their construction. The steel columns carrying the cross girders on which the bridge slabs rest are built in all cases on circular concrete footings, 3 ft. 8 in. in diameter, which were carried down to hardpan or to solid rock at 12 to 60 ft. below the surface, the average depth being about 41 ft. The three pairs of pile bents of the temporary bridge were placed so they spanned the site of their footings and so the latter could be built without interference from them.

Over 600 of the circular column footings were built. The excavations for these footings were made in open wells which were lined with 3x6-in. tongue and grooved lagging, in 5-ft. lengths, with two 2-in. iron rings to the length. The materials encountered varied from soft black mud to hardpan, although most of the digging was through stiff blue clay. Quicksand was encountered just above the rock in many of the holes and entailed considerable expense in several places. Water was also the source of no small amount of trouble while the wells were being sunk. The excavation was all made by hand, one man working in a well. The concrete in these wells was mixed in the proportion of 1 part cement to 6 parts gravel. The footings cost on the average, excavation, concrete and all, $6.30 per foot of depth. Spread footings on piles could probably have been built slightly cheaper, but the necessity for absolutely stable footings to carry the heavy floor slabs and the loads on the latter made the concrete footings down to rock the more feasible.

The steel girders and cross girders of the bridges were erected between the bents of the temporary bridges after the concrete footings were completed. The temporary bridges were then removed at the desired time with the assistance of the locomotive crane used in handling the slabs. These bridges were designed so this removal work could be done very readily. The pile bents are capped transversely with 12x14-in. timbers which are drift-bolted to them and carry three or four 8x16-in. stringers under each rail of the tracks, depending on the span. The stringers overlap at the ends with the adjacent ones of the next span and are drift-bolted to the caps on the piles. When a track is to be thrown out of service it can be shifted on the stringers to the adjoining track and the stringers and caps of the abandoned bridge pulled immediately by the crane without requiring the removal of any side bolts.

The slabs are loaded on flat cars at the storage yard by the locomotive crane, one slab to a car, and are hauled on these cars to the bridge in which they are to be placed. The crane is then set at the edge of the bridge and just back of the position the first slab is to occupy. Its outrigger arms are blocked up on the fill and it is anchored to the track with rail clips to prevent any tilting when the heavy slabs are being moved from the cars to position. The same toggle frame used at the storage yard is employed again in setting the slabs. The crane can place two or three slabs from one position; when a span for one track is complete the latter is laid and the crane is run out to place the slabs for the next span. About four slabs can be placed each day on the average.

The tops of the steel girders on which the slabs rest are covered with sheet lead and then with cement mortar just before the slabs are set, the bridge seats on the abutments also being covered with mortar before the slabs are set on them. The slabs are made so as to have a clearance of ¼ in. between them at the bottom and 1 in. at the top on both sides and both ends, their ends and sides being battered. These spaces are filled with water-proofing, making the whole bridge floor watertight.

These bridge structures when completed have a practically noiseless bridge floor which requires no maintenance and is easily inspected at all times. The concrete slabs cost $11.80 per cubic yard to build up to the time they are started away from the storage yard; transportation from the storage yard and placing in the bridge costs $2 per cubic yard additional. At these figures, the cost of the bridges in which they are used is stated to be well below that of bridges with steel girders and floors. The cost of making the slabs is believed to be above what the remaining slabs will cost, for several reasons. First, the crews employed in making the slabs were, as a matter of course, inexperienced, because no similar work had been done; second, only a single track was available at the construction and storage yard, whereas if a second track could have been used the work would have progressed with less interruption, and, third, after the rather expensive foundations for the forms had been prepared, the decision was made to enlarge the yard in which the work had been done, so new foundations had to be prepared at another site for the slabs that are to be cast this season.

The decision has been made to use reinforced-concrete columns and cross girders for the bridges to be built in 1908, instead of the steel columns and girders used in the bridges that are now being erected. The details of the reinforced-concrete columns and girders are shown in one of the accompanying illustrations. Where these reinforced-concrete columns and girders are used it is expected the bridges will require practically no maintenance.

The bridges were designed, built and erected, with the exception of the fabrication and erection of the steel, by the regular forces of the bridge department of the Chicago, Burlington & Quincy Ry., of which Mr. C. H. Cartlidge is engineer. Mr. G. E. Tebbetts as office engineer of that department had charge of the details of the design; Mr. F. L. Stone, district engineer, is in charge of the track elevation work, all of which is under the general direction of Mr. W. L. Breckenridge, engineer of lines east of the Missouri River.

Methods and Results of the Wisconsin Water Power Survey.

The value of water power as a natural resource of a State so far from coal mines as Wisconsin, led the legislature in 1905 to appropriate $2,500 for a survey of the most important rivers. This sum was duplicated by the U. S. Geological Survey and a co-operative State and Federal survey was undertaken, the organization and supervision of the work being intrusted to Prof. L. S. Smith, of the University of Wisconsin. The following information regarding the methods and results of operations during 1905 and 1906 are taken from an article by Prof. Smith in the "Wisconsin Engineer."

A feature of the field methods was the use of the magnetic needle for the control of all the directions. The change resulted in such a large saving to the State, without sacrificing any needed accuracies, that it may be briefly stated. On other similar joint State and Federal Surveys, it has been the custom to run an accurate transit or meander line along the bank of the rivers. The points occupied by the transit were accurately marked by stakes and the true direction or bearing of each line was noted, both looking forward and backward. This required all the stations to be occupied by the transit in order that the instrument might be properly oriented with respect to the meridian. Of course this secures great accuracy of location, but it is too expensive for preliminary surveys of this character. Especially is this true of a State like Wisconsin, in which the magnetic needle is fairly reliable, when properly checked by stellar determinations. Accordingly, all the surveys have been made with the "transit and stadia method," all directions being determined by the needle. This has increased the speed of the work by about 33 per cent.

Total and Unit Cost of Wisconsin Cooperative River Survey, 1905-1906.

River Surveyed	Spirit Leveling — Total Miles	Spirit Leveling — Total Cost	Spirit Leveling — Cost per Mile	Topography — Total Miles	Topography — Total Cost	Topography — Cost per Mile	Maps and Profiles — T'l Mls. Mapped	Maps and Profiles — Total Cost	Maps and Profiles — Cost per Mile	Reconnoissance and Superv's'n per Mile	T'l Cost per Mile	Total Cost
Wisconsin	187.3	$403	$2.16	197.0	$981	$4.97	197.0	$171	$0.89	$0.73	$8.61	$1698.00
Eau Claire	0.0	0	0.00	25.8	177	6.87	25.8	11	0.44	1.00	8.29	213.80
Peshtigo	40.0	194	4.85	81.7	521	6.36	81.7	40	0.50	0.70	9.98	815.20
Black	69.3	213	3.10	63.0	213	3.38	63.0	57	0.90	1.10	8.76	552.30
Flambeau	102.0	467	4.58	119.5	796	6.69	119.5	106	0.90	1.25	12.71	1519.00
Total	398.6	$1277	$3.24	487.0	$2,688	$5.52	487.0	$385	$0.79	$0.90	$9.85	$4798.30

Method: transit and stadia with wye level control. Scale; 1 in. = 1000 ft. Contour interval, 10 ft. on land and 1 ft. on water. Section lines frequently located.

The government specifications required that lines of accurate wye levels should be run in each river valley and permanent bench marks established for the control of the transit topography. Four hundred miles of such levels were run at an expense of $1,277, or $3.23 per mile. The cost of these levels varied from $2.16 per mile, in a settled country with good roads, to $4.85 per mile in a wild country, devoid of settlements and roads. Primary levels (double rodded line) on river surveys in Maine cost $10.60 per mile, and $9.13 in Virginia during 1905-6. It is extremely doubtful whether much increase in accuracy is gained by a double rodded line. Accumulative errors can be best eliminated by running the line forward and backward.

The work under discussion abundantly proves that the transit is capable of running levels with all needful accuracy for the work under discussion. The $1,277 spent on wye leveling in Wisconsin was not, however, quite thrown away. The checks thereby provided have shown so conclusively that the transit alone is sufficient that at a recent conference of the United States Geological Survey officials, the wye level was officially abandoned for river surveys.

As little on the subject of the accuracy of transit leveling has appeared in engineering literature, it will be of interest to examine in detail the checks on the Wisconsin work. In judging this work, it should be kept in mind that the turning points were far apart, on the average 1,600 to 2,000 ft., and that the men doing the work had had no topographic experience, except such as is afforded by the summer school of surveying. It was noticeable that the accuracy improved as experienced was gained in the work.

In the stretch of 58 miles of levels run on the Black River the largest error per mile on any stretch was 0.33 ft. and the average error per mile was .15 ft. These errors compensated to a remarkable degree. Thus, at the end of 10 miles, 20 miles, 31 miles, 41 miles and 51 miles, the accumulative errors were .03, .05, .04, .06 and .04 per mile respectively, while the error of the entire 58 miles was less than .01 ft. per mile, or .067 √ miles. This accuracy is about as good as is usually secured by short sight and with an accurate wye level.

The same engineer next surveyed the Flambeau River, with even better results. His largest error on any stretch was .22 ft. per mile, with an average of .09 ft. Of the 31 checks, 14 showed minus and 17 plus errors. This compensation of errors is also seen by a comparison of the accumulative errors at 11, 23, 31, 42, 50, 61, 73, 81 and 92 miles from the beginning. The error was .47, .72, .48, .08, .08, .08, .51, .89 and .26 ft., respectively. The criterion for good wye leveling (.05 √ miles) would have meant an allowable error of 0.48 ft. in this length of 92.3 miles, as compared to .26 ft. actually secured.

On the Wisconsin, about one-third of the turning points between Grand Rapids and Kilbourn, a distance of 90 miles, were taken with vertical angles. The largest error in any stretch of river is .19 ft. per mile, the smallest .01 ft. per mile, and the average error per mile only .04 ft. The largest error was near the beginning of the line, and it quite steadily decreased until at the end the total error of 200 miles of transit levels was only 0.57 ft. The total error which might be expected from a line of 200 miles of wye levels is .75 ft. The record of work on this river in which only level readings were taken on turning points (110 miles) is still better; the average error on the 9 checks was .032 ft. per mile.

Eighty-two miles of transit levels were run on the Peshtigo River, the greater part being in a rough, rocky and sparsely settled country; 50.2 miles of these transit levels were checked by wye levels. The largest error per mile in any stretch was .23 ft., the smallest .02 ft., and the average .09 ft. The largest accumulation of error at any point was 1.64 ft. while that at closing was .98 ft. The accumulative error per mile gradually decreased from .09 ft. near the beginning to .02 ft. at the end.

Attention is directed not so much to the small size of the errors as to the fact that the errors compensate to a remarkable degree. It is perfectly manifest, in Prof. Smith's opinion, that the transit as a leveling instrument is capable of doing leveling with an accuracy well within the limits required on preliminary surveys of this character. The omission of the wye leveling on this work will save many thousands of dollars in future work of this character.

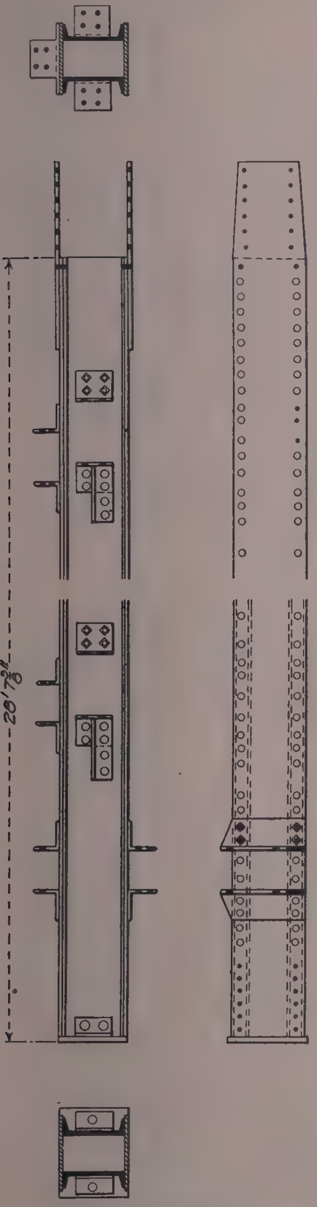
The collection of the data shown in the accompanying table has cost much labor and study. In it the cost of 487 miles of river surveys is separated into its four principal items: Wye leveling, topography, office mapping and supervision. For 187.3 miles of the Wisconsin River, these items totaled $1,698, or $8.61 per mile; 25.8 miles on the Eau Claire cost $8.29 per mile without leveling; 81.7 miles of Peshtigo River survey cost a total of $815.20, or $9.98 per mile; the unit cost on Black River was $8.76, while that on Flambeau was $12.71. The reason for this excessive cost is found in the fact that the work was greatly interrupted by storms. This necessitated three trips of the party from Madison to this river, causing large expense for transportation. Thirty-eight days in all were lost because of travel, stormy weather and holidays, including Sundays, the cost of which was $418. Could this delay have been avoided, the cost per mile would have been reduced to $9.21. The average cost of the 487 miles of the river surveyed and mapped was $9.85.

It may be of interest to compare this with the table of cost of similar work in Maine during 1905-6. The average of such cost of completed maps as far as is shown is $17.40, or nearly double that of the Wisconsin work. The forest, geological and other features controlling the cost are quite similar in the two states. In Virginia, where the conditions for doing such work are much less favorable, 130 miles of river survey cost in 1905 $4,101, or $31 per mile. This included $9.13 per mile for primary levels. The reduction of the cost of river survey to less than $10 per mile is due primarily to the changes introduced in party organization, together with the simplification of field methods. The cost of supervision also was very little, probably not one-half of similar work in the East.

Gas Engines will be used in the power plant of the Milwaukee Northern Electric Ry.

Structural Details in the Singer Building, New York.

The northern addition to the Singer Building, New York, is a 14-story steel cage office building, about 115 ft. deep, with a frontage of 75 ft. on Broadway and a central tower 63 ft. square and 612 ft. 1 in. in height above the curb, as was described in The Engineering Record of September 8, 1906. The superstructure is supported on 58 steel columns with closed rectangular cross sections made with pairs of channels and cover plates, four of them are light basement columns, supporting the first floor only, 18 reach to the main roof and the 11th and 12th stories and the remainder extend above the top of the main roof to form part of the tower frame-work and terminate above the 36th and 43rd floors.



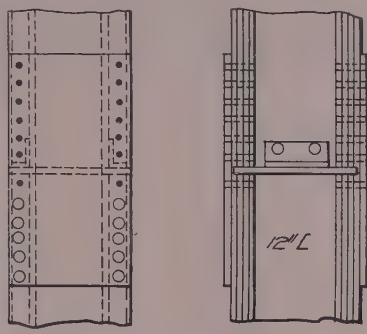
Wall Column, P47.

The columns are proportioned according to the building law to carry the entire dead load, and a certain proportion of the live load diminishing from above downward until it reaches a minimum of one-half the theoretical live load per floor, which is assumed at 75 lb. per square foot for all except the ground floor, on which 150 lb. is calculated.

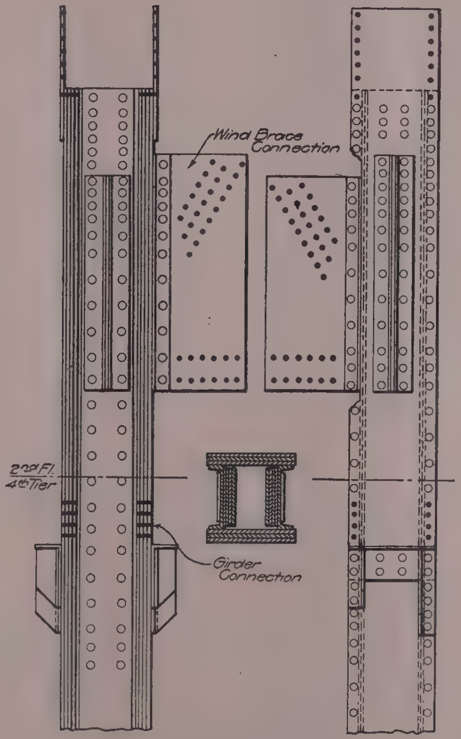
These loads give a maximum column stress of 1,854,000 lb. Beside the static loads some of the tower columns receive heavy wind stresses from an assumed pressure of 30 lb. per square foot on the exposed surface. This amounts to as much as 1,517,000 lb. maximum and may, of course, be positive or negative according to the direction of the wind. In the former case it is added to the static load. The maximum wind stress does not occur with the maximum static load, in which case the wind load amounts to 1,422,000 lb.

In five columns this is provided for by a cross-sectional area of 235 sq. in. This is made up with two 15-in. x 55 lb. channels, four 20-in. x ⅞ lb plates, two 20 x ¾-in., eight 14 x 13/16-in. and two 12 x ½-in. plates.

The 20-in. plates are in all cases used for flange covers, and lighter sections of columns are made with 12-in. channels and 14-in. covers, with 10-in. channels and 12-in. covers, and with 8-in. channels and 10-in. covers, all four sizes being sometimes used in the same column, commencing at the top and increasing downward. Typical splices are made, as shown in the detail, with a pair of jaw-plates shop-riveted to the flanges of the upper end of the lower section of the column and field riveted to the lower end of the upper section and forming covers over the edges of a horizontal diaphragm, shop-riveted to the lower end of the upper section of the column. The columns are made in 2-story lengths, except in the 14th, 15th and 16th stories, which are covered by a single 3-story length and in the cellar, basement and 1st story, where the construction is irregular and the lengths vary from one to three stories. The basement has a height of 12 ft. 4 in. The first story, 17 ft. 9⅜ in., the second, 14 ft. 5⅛ in., the mezzanine story between the 13th and 14th stories, 8 ft., the 41st and 42nd stories 9 ft. The average height of the other stories is 13 ft. 4 in.

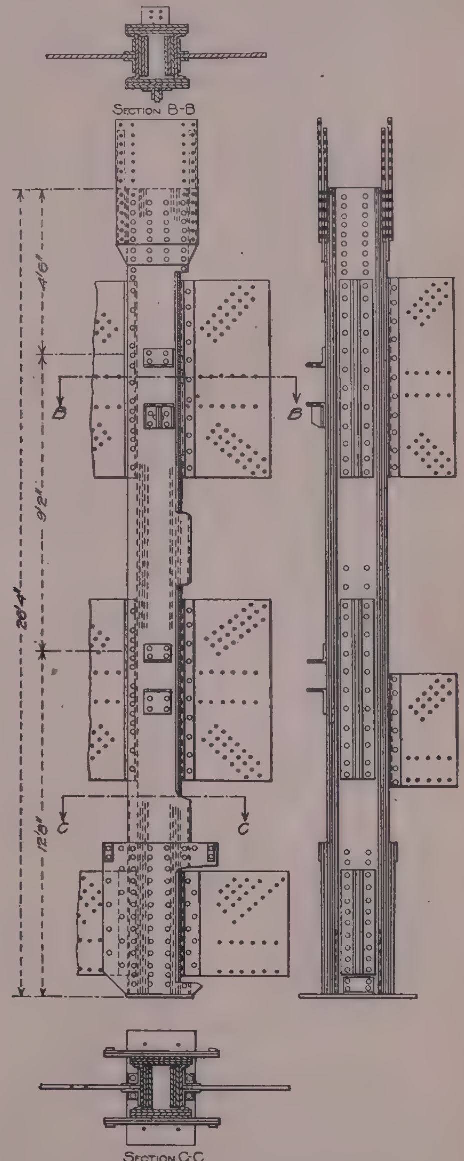


Column Splice.



Corner Column, P6.

The column details are very simple, as is indicated by the elevation of column C13-19, which is typical of the basement sections of both wall and interior columns. Both beams and girders have their top and bottom flanges connected to the column with horizontal angles, shop-riveted to the column, and field riveted to the girder. The horizontal flanges of the lower angles are reinforced by vertical distributing angles with their upper ends milled to bearing when the loads are sufficient to require it. The upper sections of the columns correspond to the lower ones as indicated by the drawing of column C47, in the 2nd and 4th story. This is a wall column, but does not differ materially from the interior columns.



Elevator Shaft Columns 16-10 and 21.

The interior columns in the elevator and stairwell framing are special in that they receive heavy wind stresses from the X-brace systems connected to one or more faces through large vertical gusset plates shop-riveted to their flanges and covers. Column C6 is typical of the upper portion of the columns and shows the connection at the 4th floor. The lower sections of these columns have heavy wing plates riveted across their flanges at the lower end with their projecting upper edges faced to give bearing to the cast steel saddles illustrated on May 4 for the connection of the adjustable vertical anchorage rods provided for maximum wind stresses. Each wing is made with a pair of ¾-in.

plates shop-riveted together, giving a section which, considered as a column, is sufficient to transmit the entire upward reaction to the anchorages.

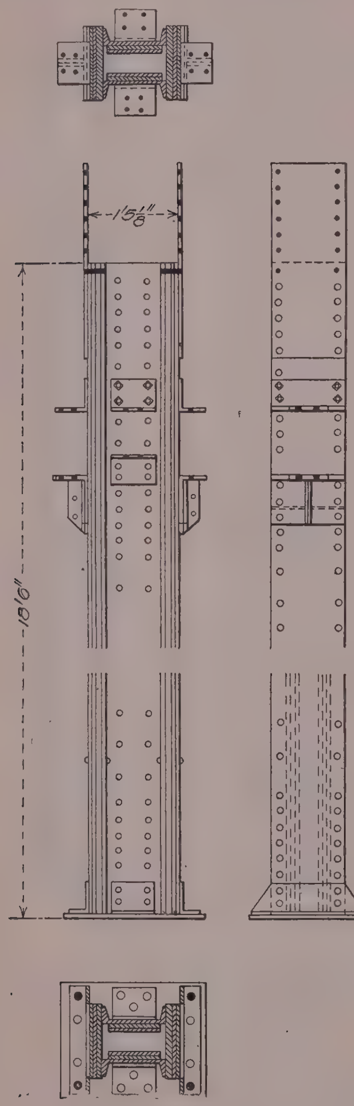
In the first and second stories architectural considerations required that the corner column 50, seated in the south side wall, should be set back 6 ft. from the intersection of the lot line. Above the third floor this column is moved forward into the plane of the Broadway front wall. In order to accomplish this, the 12 upper stories of the columns are carried on the overhang of a triple-web cantilever girder fulcrumed on the top of the lower story of the No. 50 column and anchored at the opposite end by an indirect connection to the adjacent column No. 37. The column has a standard lower section extending to its pedestal in the cellar and is provided just below the third floor with a cap plate field riveted to the flanges of the girder. The edges of the cap plate are all reinforced by bearings on the upper ends of vertical distributing angles riveted to the faces of the columns.

The girder, about 30-in. deep and 18 ft. long over all, is proportioned for a moment of 2,200,000 ft. lb. It really consists of three plate girders united by the flange cover plates so as to be integral and form a closed box cross section with a center web or diaphragm. It has four 6 x 4 x ⅞-in. flange angles for the center web and two 6 x 6 x ⅞-in. flange angles for each outer webs. Each web is a 27 x 1-in. plate, the outer ones being reinforced by a single 25 x ⅜-in. plate, which covers the length of the flange angles and is seated on a 15 x ⅞-in. full length filler plate. There are two 25 x 1-in. and two 25 x ½-in. full length cover plates. At each end over the top of the fulcrum column No. 50, the webs are reinforced by pairs of vertical angles riveted to their outer faces to provide for the concentrated loads. The load of 504,000 lb. on the upper part of column 50 produces an uplift of 78,000 lb. at the inner end of the girder, which is provided for by its bearing against the underside of a pair of 15-in. I-beams, about 5½ ft. long, which are bracketed out from the face of column 37 and support a portion of the tall masonry wall above which serves as a counterbalance.

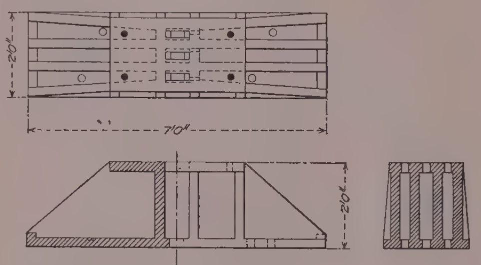
There are 45 tiers of floor beams in the building and in the tower. The 6th tier is typical of the beam plan for the main girders up to the 14th story, and as shown in the diagram is generally divided into uniform 12-ft. transverse and longitudinal panels, thus making regular short spans which promote economy of beams. In the Broadway front the column spaces are greater on account of architectural considerations, and in the first row of interior columns parallel with it two intermediate columns are omitted, thus doubling the spans and necessitating the use of pairs of 15-in. I-beams for girders, elsewhere most of the girders are single 12-in. I-beams and the floor beams are 8-in. I-beams 4 ft. apart.

In the Broadway front and for part of the north wall, the masonry is carried, independently of the floor system, on 10 and 12-in. I-beams connected directly to the outer faces of the columns. Part of the north wall is carried on 12-in. channels bracketed out from the faces of the regular floor girders. Another portion of this wall, which incloses a light court as well as a part of the south wall, is carried on single and double girders supported by the projecting ends of the regular floor beam girders which cantilever beyond the wall columns to receive them. In other places most of the wall is occupied by bay windows projecting about 4 ft. beyond the column centers and having their steel frame-work carried by the cantilever ends of the regular floor beams, which are fulcrumed on the floor girders connecting the column centers. The panels, about 2 ft. wide between the main cantilever floor girders, are occupied by pairs of parallel 12-in. channels with angle shelf brackets to receive the flooring.

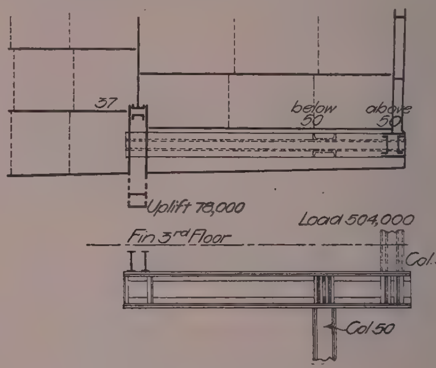
Most of the columns are seated in pairs, one at each end of the comparatively long and narrow rectangular concrete piers to which their loads are transmitted by grillages consisting of single tiers of full-length longitudinal I-beams of depths calculated to make a practically uniform distribution of the pressure and reduce the deflection to a very small amount when the beams are considered as double-balanced canilevers supported at column centers and loaded over the full length of their opposite flanges. The I-beams are in groups of 5 to 10 and are either 15 in. or 24 in. deep as required. They are spaced with standard cast-iron separators and tied together with horizontal screw rods in the usual manner, the interstices between their webs and space around them being carefully concreted. In most cases the columns supported by the different piers are



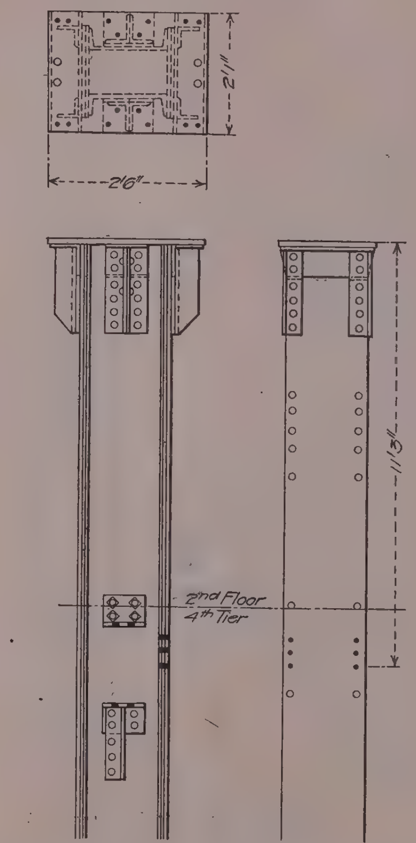
Wall Columns, P13-19.



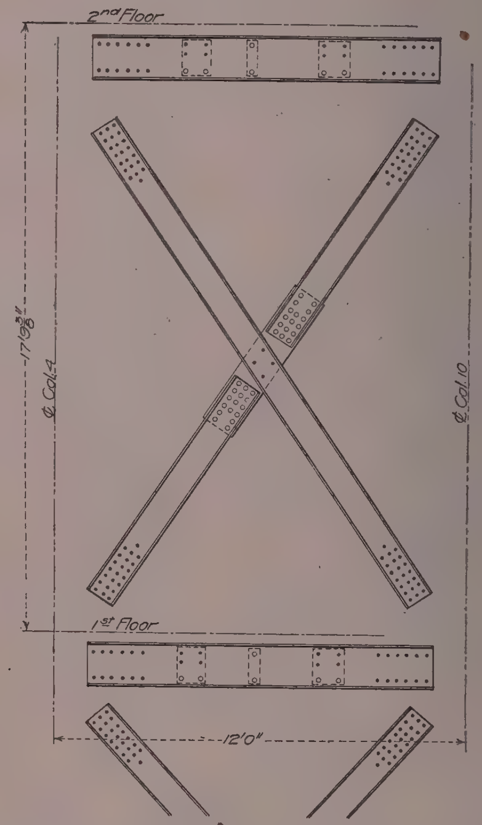
Cast Steel Pedestal.



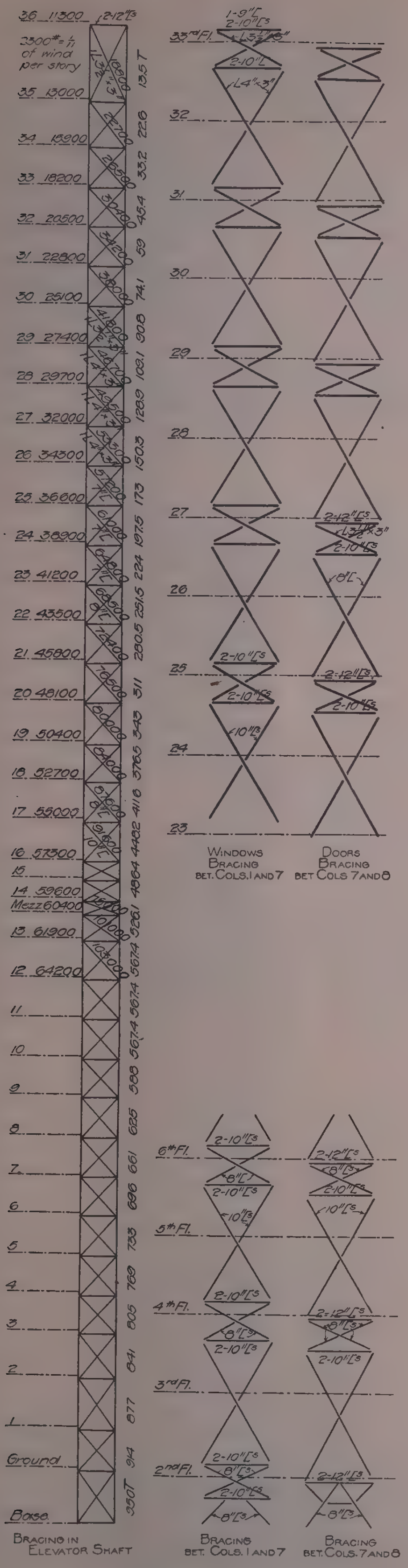
Cantilever Girder.



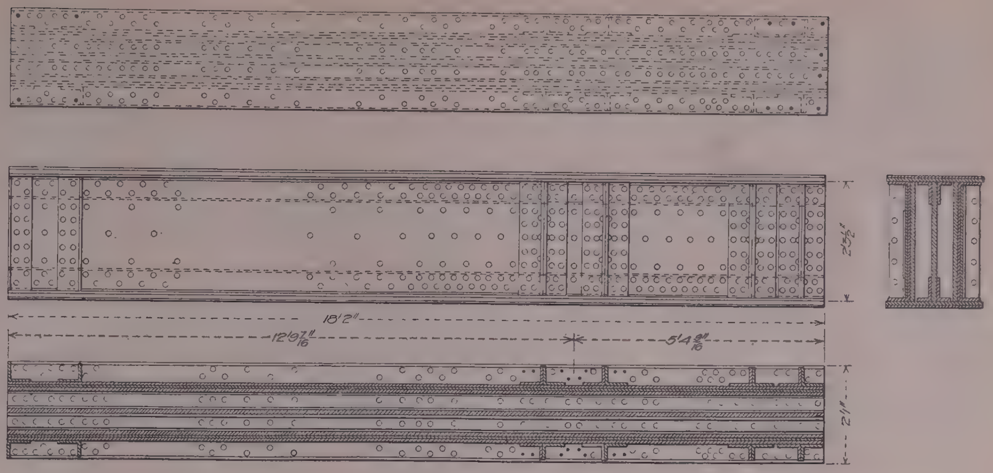
Corner Column, P50.



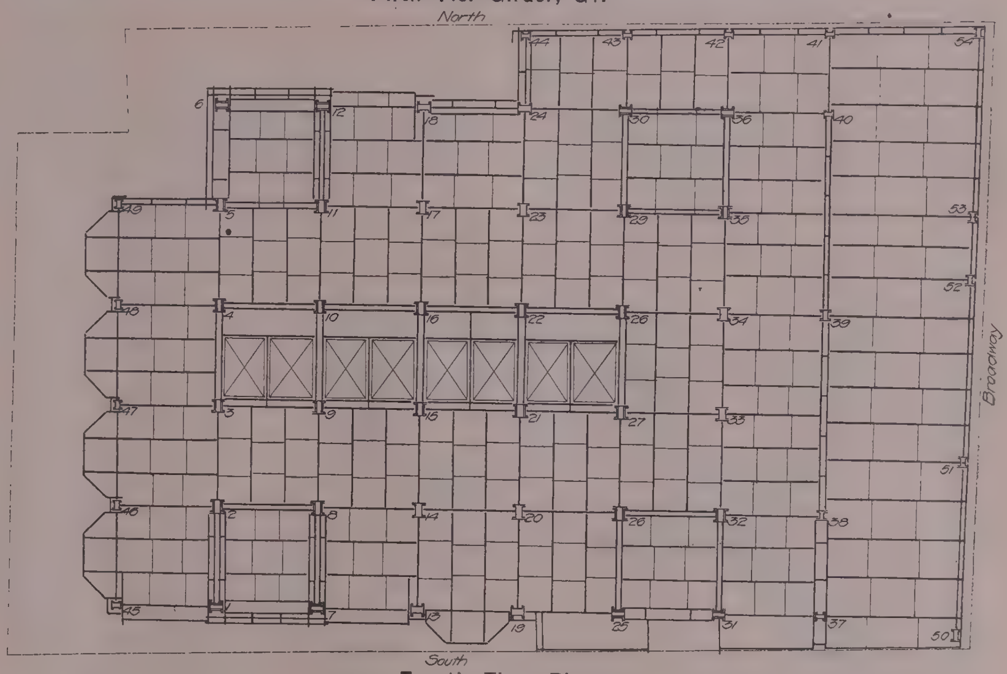
Wind Bracing Details.



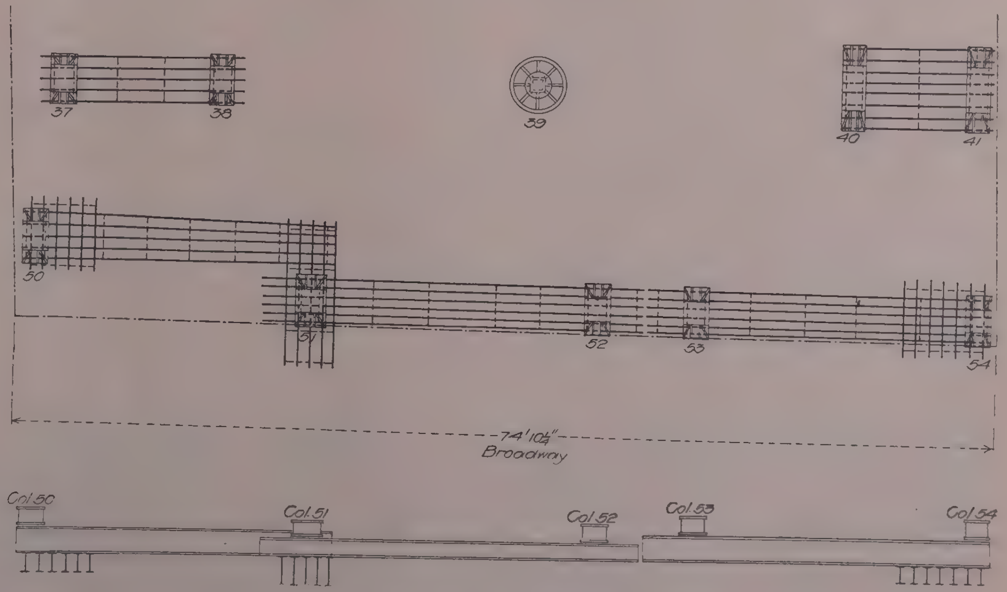
Wind Bracing Diagrams.



Fifth Tier Girder, G1.



Fourth Floor Plan,



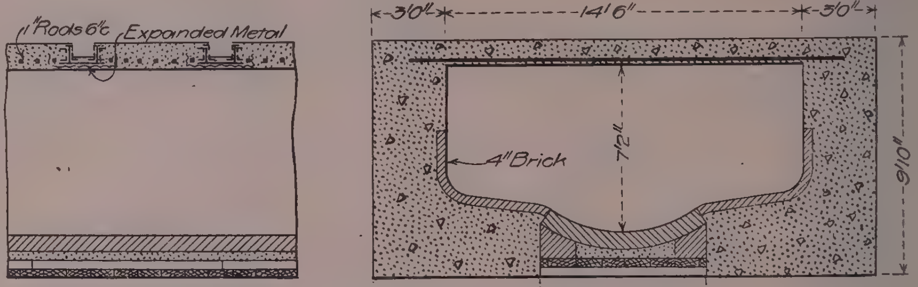
Part Plan of Grillages and Foundation Girders,

entirely independent, but at the Broadway front the irregular location of the piers led to a special arrangement and to double grillage beams, as indicated in the part plan. The corner column, No. 50, is, as already described, offset from the line of the Broadway wall, and its pedestal is seated on the extremity of an upper tier of cantilever I-beam, fulcrumed on the grillage of its pier and extending across to the next pier which supports column 51, and are there anchored to the pier grillage I-beams which receive on their top flanges a set of longitudinal I-beams carrying column 52 at their opposite ends.

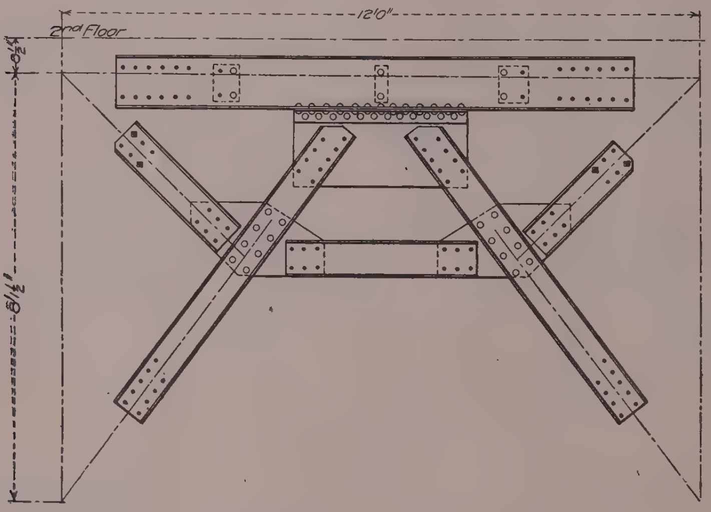
In each case every column load is uniformly distributed across the full width of its set of grillage beams by a cast-steel pedestal from 16 to 24 in. in height. Most of the pedestals have three longitudinal and two transverse webs, but those for the tower columns have to carry maximum loads of as much as 926 tons static and 711 tons wind loads and are made with four longitudinal webs about 3 in. thick. Columns 39 and 47 have special circular pedestals with bases 4 ft. and 5¼ ft. in diameter and carry static loads of 186 tons and 313 tons, respectively.

The stresses developed by an assumed wind pressure of 30 lb. per sq. ft. on the entire vertical surface of the tower are resisted by a system of 25 panels of X-bracing between pairs of columns; four of these panels terminate at the 14th floor. Sixteen panels in corners of tower are continued to the 32nd and the remainder are carried to the 36th floor, just below the dome which surmounts the tower. The arrangement of the tower bracing is special in order to provide clearance for the doors and windows which are located between or adjacent to the diagonals. To this end one pair of X-braces forms a panel of comparatively short height vertically, at every alternate floor line.

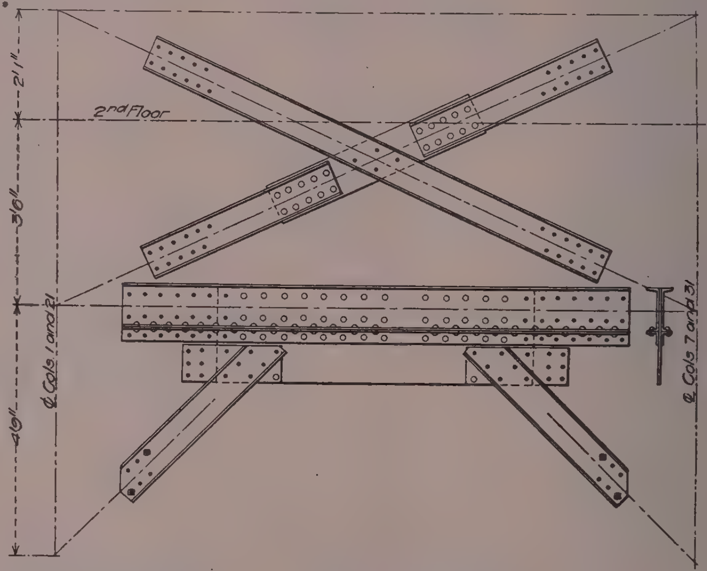
The spaces between these panels are filled with X-braces forming long vertical panels and providing wide spaces between the diagonals at the upper and lower ends, thus leaving space for a door or window between them, above and below the floor line which is intersected near the center of the panel. Alternate stories thus have their doors and windows located first in the upper and then in the lower space between the diagonals. In the panels arranged for window openings the horizontal struts at the ends of the X-braces are located approximately symmetrical on both sides of the floor line, in the door panels, the horizontal struts are both depressed just below the floor line so as to leave an unobstructed clearance for the doorway reaching down to the floor level. No knee-braces are used in the bracing system, all diagonal members being full length and provided at their extremities with special horizontal struts, thus forming with the columns complete vertical trusses extending for the full heights of the columns.



Foster Ave. Sewer, Brighton Beach Improvement.



Portal Bracings, Cols. 1-7, 2-8.



Bracing between Columns in Elevator Shaft.

In the 32d or highest regular story the horizontal struts of the wind-brace system at windows and doors are made with pairs of 10-in. 15-lb. channels, back to back, and the X-braces are made with single 4 x 3-in. x 8½-lb. angles, for the long panels; and with 3 x 3½-in. x 6.6-lb. angles for the short panels. In the 30th story the long diagonals change to 7-in. 12½-lb. channels and in the 28th story to 8-in. 13¾-lb. channels, in the 24th story to 10-in. 20-lb. channels, in the 20th story to 10-in. 25-lb. channels, and in the 14th story 10-in. 30-lb. channels, which are maintained to the basement story. The short diagonals change at the 23rd floor to 4 x 3 x 8½-lb. angles, and at the 19th floor to 7-in. 5¼-lb. single channels, at the 12th floor to 8-in. 12¾-lb. channels, which continue the same size through the remaining stories to the basement.

In eight panels the wind braces terminate at the 2nd floor and in eight panels they are carried down about 8 ft. lower with knee-braces and semi-diagonals. In nine sets of bracing below the 12th floor all panels have full-length diagonals without special provision for window or door openings. In these panels the horizontal struts are all pairs of 15-in. 33-lb. channels and the diagonals are single 10-in. 30-lb. channels. In five panels the bracing terminates at the basement floor where the columns are seated on the grillages and transmit the wind stresses directly to the foundation. In three panels the bracing is extended one story lower to reach the lower end of the columns at the pump room floor.

The regular bracing corresponds to the first story shown and all members are shipped separately and field riveted together at the intersections of diagonals and at extremities to the connection plates shop-riveted to the column. As the webs of the diagonal channels are in the same vertical plane, one of them is cut to clear the other and is spliced across it by a web plate shop-riveted to both pieces and field riveted to the intersecting channel. The portal bracing between columns in the 2nd floor is of two types, one having simple knee-braces connected to vertical web plates riveted between the channels forming a horizontal strut and projecting below their lower flanges, and the other type having semi-diagonals attached to the lower flanges of the horizontal struts and braced at their center points with horizontal and diagonal members.

The roof over the 14th story of the building outside of the limits of the tower is, on the Broadway front, of mansard construction, supported of curved rafters from about 2½ to 6½ ft. apart. Each rafter is made with a pair of 10-in. 25-lb. channels riveted together, back to back, and carrying on the outer flanges horizontal T-bar purlins 25 in. apart. The seats of the rafters are connected to the 12th floor wall girders just below the level of the finished floor, and above this point they are vertical for 4½ ft., where a curve of about 26 ft. radius commences and brings them in to their web connections with the girders in the 13th mezzanine floor 28 ft. 9 in. above the 12th floor and about 16¼ ft. horizontally from the lower end of the rafter. The rafters curve inward from their lower ends about 1½ ft. to the point where they are connected to the 13th floor beams, and just above that level the upper and lower sections are field spliced together with flange and web cover plates. The 18-in. I-beam which receives the upper end of the curved rafter and resists a considerable lateral stress is stiffened by having a 12-in. channel riveted to its lower flange, thus forming a T-shape cross section of considerable rigidity.

The cornice at the top of the mansard roof is anchored to and supported by a series of A-shape angle iron frames about 4 ft. high, which are seated on the rafters and on the T-shape beams and are braced together by three lines of horizontal T-bars and angles on the side nearest the tower. Their upper ends are connected by a continuous 6-in. channel with horizontal webs to which short 3 x 3-in. horizontal transverse T-bars are riveted. Alternate panels between the mansard rafters are provided with square and circular skylights having angle iron frames riveted to their outer flanges.

Mr. Ernest Flagg is the architect of the building; the structural work was designed by his engineering staff, Mr. O. F. Semsch, chief engineer. Messrs. Boller and Hodge are the consulting engineers. The contract for the fabrication and erection of the steel work was awarded to Milliken Bros.

The Raveling of State highways in Massachusetts during dry weather has generally been prevented in the past by spreading a thin coat of sand over the surface. During last year, however, there were two quite protracted dry spells which disturbed the bond of the road and caused loose stone to stand up on the surface. Although sand was spread thinly as before, it did not prevent the raveling in all instances.

Trench for Retaining Wall.

Shovel Cutting out Core.

The Brighton Beach Improvement of the Brooklyn Heights R. R.

The Brooklyn Heights R. R. Co., in connection with the Brooklyn Grade Crossing Commission, is making extensive changes in its Brighton Beach line to Coney Island. The main part of the work is about 5 miles long, and was undertaken to abolish grade crossings. The line was formerly the property of a steam road, the Brooklyn & Brighton Beach R. R., which terminated in a depot at Atlantic Ave. and Franklin Ave., Brooklyn. When the property was acquired by the present owners the depot was abandoned and an incline built to connect the line with the elevated road in Fulton St. As heretofore operated, the road dropped down from the elevated structure into an open cut which extended to Church Ave. in Flatbush, where it came to the surface and continued at street grade to Brighton Beach. The main part of the present work is the reconstruction of this latter stretch, south of Church Ave., the first 1¼ miles being placed in an open cut, and the remainder on an embankment.

The reconstruction is being done under authority of an act of the Legislature, passed in 1903 and amended in 1905, which established the Brooklyn Grade Crossing Commission, whose duty it is to prepare the plans and specifications and superintend the execution of the grade crossing elimination work. The Commission consists of five members appointed by the Mayor of New York, one being nominated by the Long Island R. R., and one by the Brooklyn Heights R. R. The cost is to be equally divided between the railroad company and the city, except that the limit of the city's expenditure is $1,000,000.

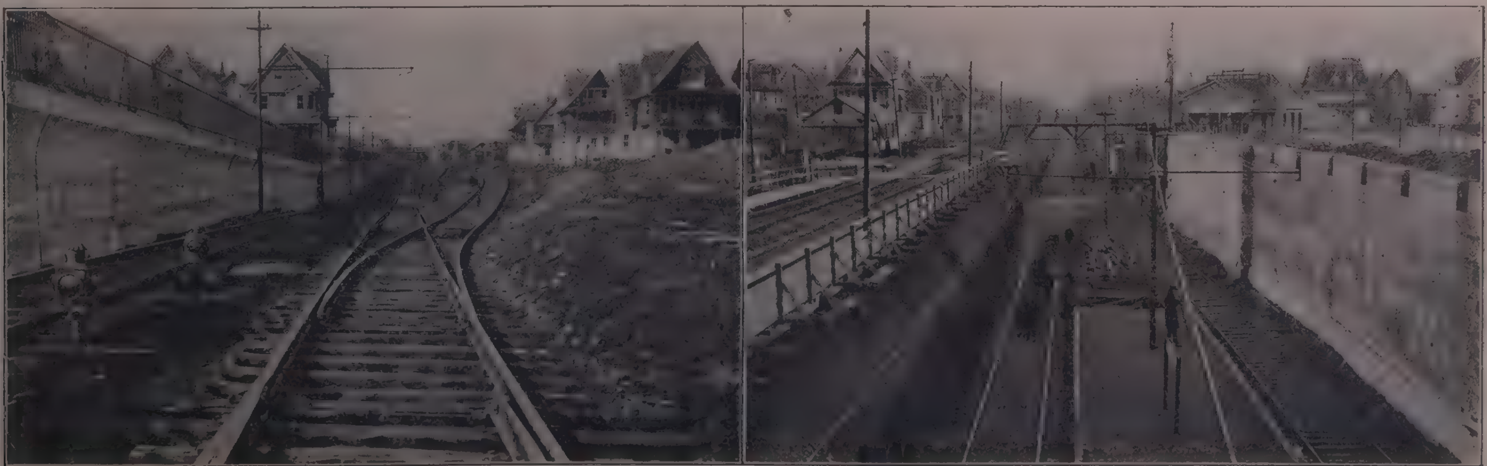
The Brighton Beach line from Church Ave. south serves a rapidly growing residence section, and this fact, in addition to the very large summer traffic to the Coney Island resorts and the Sheepshead Bay and Brighton Beach race tracks, influenced the railroad company to build a four-track system on the new work to replace the two tracks now in operation. When the improvement is completed an express service will be inaugurated on the two inside tracks. Work was started on Dec. 30, 1905, and it is hoped to have it sufficiently completed by June 15 of this year to operate two tracks in the cut and on the embankment.

The reconstruction described in this article starts near Church Ave. The roadbed for 1¼ miles south of this point will be depressed 10 to 22 ft. below street grade, the sides being protected by concrete retaining walls and the depression spanned by plate girder bridges carrying the streets. The grade finally rises to cross over the tracks of the Bay Ridge division of the Long Island R. R., and for the remaining distance the roadbed will be elevated about 12 ft. above the ground on an earth embankment.

The material in the cut, amounting to 230,000 cu. yd., was sand and gravel, and this fact, combined with the high value of the property bordering the right of way, made it cheaper to build retaining walls than to purchase extra land for slopes. The walls under 14 ft. have a vertical face, and the higher ones a recessed face with curves joining it to the faces of the coping and the footing. The walls are built on an easement of 7 ft. granted by the owners of the abutting property. They are of 1:3:5 concrete made with Giant Portland cement and rest on gravel foundations about 3½ ft. below the roadbed. Vertical expansion joints with a V-shaped groove on the surface are left every 50 ft., tar paper being used to separate the abutting sections. In the interior of the wall are placed vitrified clay conduits for carrying wires. They are made up of sections 18 in. long, with the joints wrapped with 2 laps of cloth 6 in. wide, dipped in cement grout before being applied. Manholes for handling the wires are built into the walls every 400 feet.

The problem of draining the cut proved a difficult one. It was desirable to avoid raising the streets passing over it, but to do this would have required a depression of the roadbed which would have made gravity drainage impossible. A compromise was therefore effected which, with the use of very light drainage grades, allowed the run-off to be diverted to the city's sewerage system. Concrete troughs are built the full width of the right of way at intervals of about 600 ft., and connected with a drain which runs the full length of the cut. This system is connected with the city system through a 36-in. sewer 1½ miles long. The transverse troughs vary in width from 18 to 24 in. They are covered with iron gratings and are spanned by yellow-pine stringers 10 in. square carrying the rails. In addition to this system, rapid drainage is provided by ditches lined with granite blocks, with a covering of cement grout, located between the outside tracks and the retaining walls.

At one street intersection a 10-ft. circular sewer crossed the right of way at an elevation which required rebuilding it. The street was torn up for 60 ft. on each side of the railroad property lines and the sewer reconstructed with a section having an extreme depth of 7 ft. 2 in. and a width of 14 ft. 6 in. Part of the old invert was left undisturbed, and a flat roof of reinforced concrete and vertical side walls built around it. The rails for the track are carried over the roof in steel troughs. The flow in the sewer was not obstructed at any time, a flume of sufficient size to care for a moderate storm having been built



Cut during Construction, Brighton Beach Improvement.

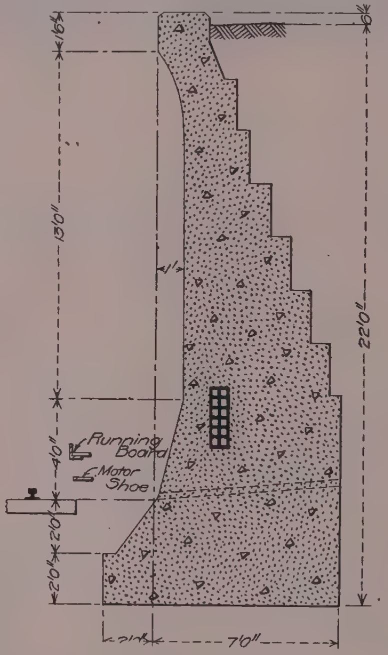
in the old sewer after the top was broken down.

The tracks begin to rise a short distance north of the Bay Ridge division of the Long Island R. R., which will be crossed by a bridge of 24-in. I-beams, 12 in. center to center and incased in concrete. Heretofore the crossing has been the reverse of this condition. Just east of this crossing a Y leads off the Long Island R. R. and a double track system runs parallel to the Brighton Beach line as far as Coney Island, the two lines being close together for a short stretch and then swinging outward, run about 600 ft. apart. Under the new plans, the old right of way of the Long Island R. R. will be abandoned and its tracks transferred to the fill on which the Brighton Beach line will be built, thus making a six-track embankment. The changes on the Long Island system are being carried on as part of the Bay Ridge improvement, which is also under the control of the Brooklyn Grade Crossing Commission. The embankment will contain about 1,000,000 cu. yd., the cut above described furnishing about 230,000 cu. yd. and the remainder coming from the Bay Ridge improvement.

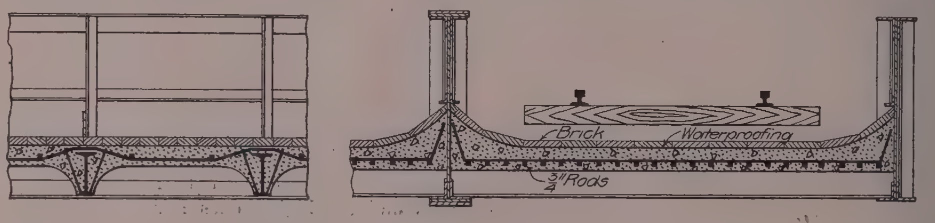
The streets intersecting the right of way are carried over the cut on plate girder bridges, and on the south end under the embankment through subways spanned by the same type of bridge. The maximum height that any street was raised was 7 ft. and the maximum gradient 3.3 per cent. The maximum street depression was 4 ft. All bridges have solid reinforced-concrete floors.

The station buildings are placed over the tracks in the cut section and under them on the embankment. Reinforced concrete, made with Portland cement, is used in the construction of the floors of buildings and platforms, and for stairways and guard railings. The stairways are solid monoliths reinforced with wire cloth parallel to the inclined under surface, and with ⅜-in. transverse rods, one beneath each tread. Owing to the fact that the platforms on the south end of the work are over a new fill, they are being built on Chenoweth concrete piles driven through the newly deposited material to a solid bearing in the undisturbed ground beneath. The platforms of the local stations in the cut are being built as part of the retaining wall and within the 7-ft. easement. The back wall and the canopy are reinforced with square bars, and the latter is carried on steel columns placed 12 ft. on centers. On account of the thin section of the wall and canopy at these stations they are waterproofed by a method which is also applied to the abutments. A wall of hollow tile was built against the back sheeting in the trench and on this wall was spread three layers of hot pitch and three of waterproofing felt alternating, a layer of pitch being the first applied. On the roof and back of the coping the pitch and felt were applied first and the tile placed after, acting only as a protection to the felt. The concrete for this work is a 1:3:5 stone and gravel mixture.

The construction work in the cut was carried on under very adverse conditions. The contract required the maintenance of traffic, and this, combined with the fact that the entire plant had to be confined to the right of way and the easement strips, a total width of 64 ft., necessitated skillful arrangement and handling. The contractor was allowed to use the operating tracks for spoil service so long as it did not interfere with the regular traffic. Work was started at the south end of the cut, near the point where the contractor had established his auxiliary plant and opened a gravel pit. A track was built on the east easement strip and used for an operating track, while the western one of the two original tracks was used for spoil service. A track was then excavated in the west easement strip, the material being shoveled by hand into tubs which were swung by a derrick over to the spoil track and dumped into cars. Operations were carried on at three points simultaneously. The trench was sheeted as the work progressed and the forms for the retaining wall put in place and concreting begun. As soon as the wall was completed for a sufficient length, a derrick operating Hayward orange-peel bucket was put in service and removed the material on the inside of the wall until a sufficient width had been excavated to subgrade to allow one or two tracks, depending on the location to be thrown into the trench. Traffic was then diverted through this cut, single-track operation being carried on for about three-quarters of a mile. The temporary track was next removed from the east easement strip and the construction of the east wall proceeded in a manner similar to that described for the west wall. When the forms were ready to be taken down a steam shovel was put in to remove the core of spoil between the two walls. A shovel made by the Atlantic Equipment Co. was used.



Retaining Wall Section.

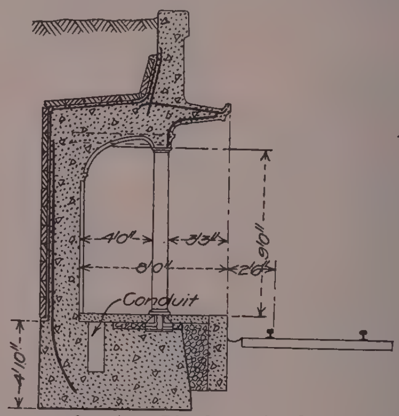


Longitudinal and Transverse Sections of Bridges.

The concrete mixers, three in number, were generally set up at the end of the blocks, and the concrete delivered to its place in the wall in cars running over the trench on a narrow gauge track furnished by the Henry J. McCoy Co. The mixers were elevated so as to discharge by gravity into the cars, the materials being raised to them by bucket conveyors. Ransome mixers were used. The total amount of concrete in the cut is about 40,000 cu. yd., and it was placed at a rate as high as 250 cu. yd. per day.

South of the Long Island R. R. crossing, the work was carried on without the inconveniences experienced in the cut. The work consisted merely in making the embankment, and since the Brighton Beach trains were operated over the Manhattan Beach tracks, no special provision for regular traffic was required. Considerable temporary bridging was required in all portions of the work in providing for street traffic.

As the material taken from the cut contained sand and gravel of the grades required for the concrete a screening and washing plant was installed by the contractor. A spur from the main track led to a depressed hopper which consisted merely of a sheeted trench beneath which ran a Robins belt conveyor for elevating the material to the screen. The spur track was high enough to discharge by gravity into the hopper, and the screen likewise was high enough to discharge by gravity into the cars provided for hauling away the sorted and washed material. Near the screening plant is a crusher made by the Good Roads Machinery Co., a gravel pit, a blacksmith shop and a cement warehouse. Owing to the high cost of water, $1 per 1,000 cu. ft., the contractor determined to secure an independent supply, and accordingly sank a 3-in. well and installed an electrically-driven pump. A supply pipe with taps every 400 ft. was laid the entire length of the work and furnished a handy supply for concrete, the engines and the steam shovel. The pump was a triplex pump with a capacity of 60 gal. per minute, and was made by the Platt Iron Works. It was driven by a 10-h.-p., 500-volt General Electric Co. motor, supplied with power from the trolley wires. The installation, allowing for the depreciation of the plant, has reduced the cost to about half of the charge for city s vice. The contractor used 3 Mogul eng weighing 60,000 lbs. each, 40 flat cars with a c city of 50,000 lbs., and 36 6-yd. Oliver dump c



Section Platform in Cut.

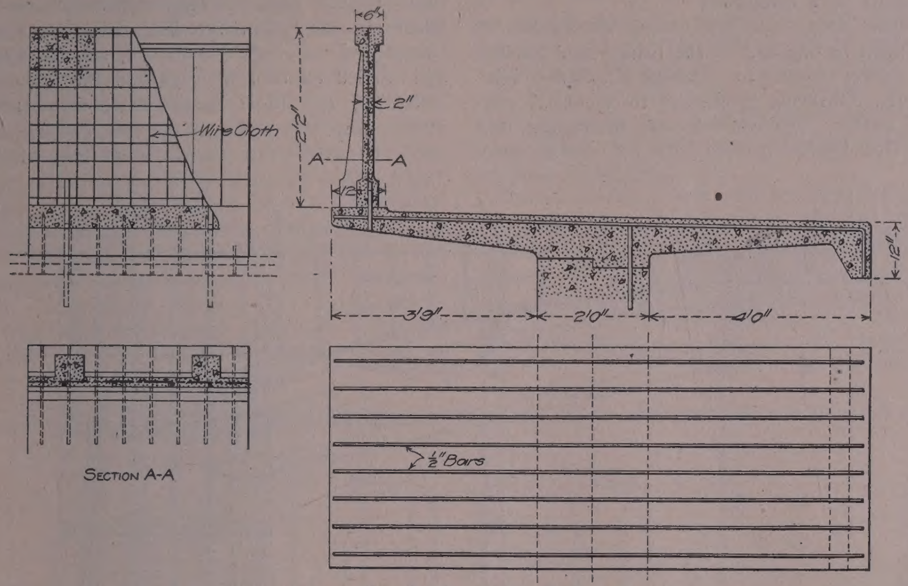
The cost of the stations, which is borne enti by the railroad, is $200,000, and the remair of the improvement about $2,000,000.

The work is under the supervision of Brooklyn Grade Crossing Commission, Mr. J. Dwyer being engineer in charge, Mr. H. B. S principal assistant engineer, and Mr. C. T. Bis resident engineer. All the work in the cut the filling as far south as Avenue O is b done by Mr. Charles Cranford, with Mr. R Russell as chief engineer. The embankr south of Avenue O and the stations are b built by the Brooklyn Heights R. R., Mr. W Menden chief engineer. Milliken Bros., N York, furnished all the steel for bridges and tions, and the Abbot-Gamble Co. built the br floors.

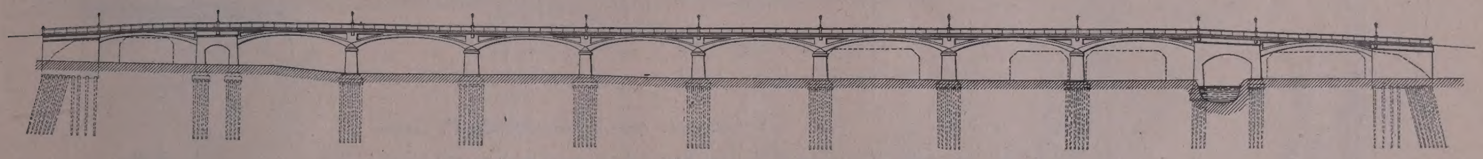
THE RAILROAD MILEAGE OF TEXAS is 12 miles of main track, according to the an report of the Railroad Commission of that S The gross earnings per mile of road for the ending June 30, 1906, was $6,182.70, the ope ing expenses $4,660.11.

The Jacksonville Viaduct.

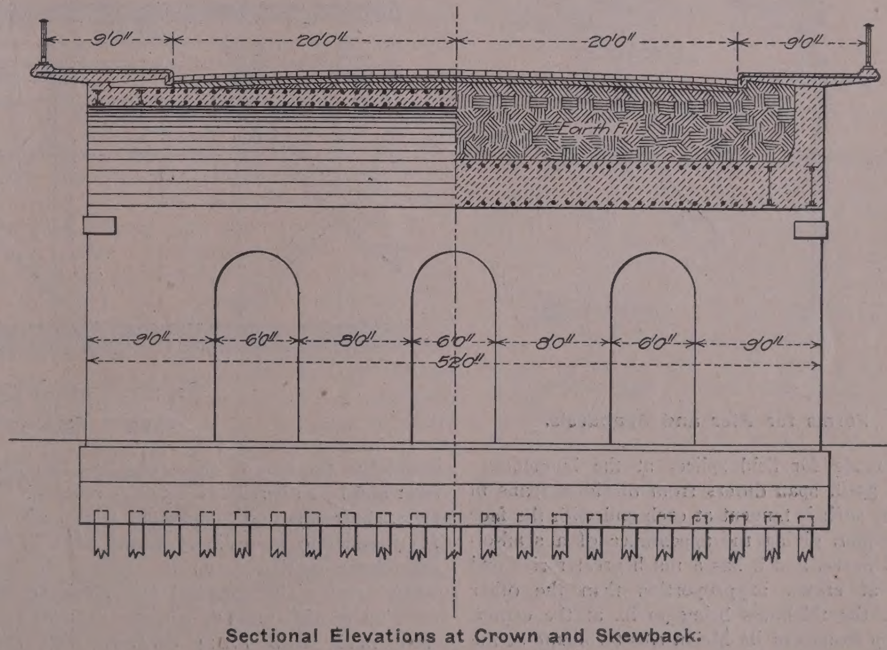
The Jacksonville viaduct is a reinforced concrete structure 845 ft. long and 60 ft. wide over all, which carries a highway, two street car tracks and two sidewalks at a maximum height of about 30 ft. above the railroad tracks in the yards of the Atlantic Coast Line, the Seaboard Air Line, and the Florida East Coast R. R. The axis is composed of several tangents intersecting at angles of 5 to 25 deg. with piers 52 ft. long measured at right angles to the viaduct axis. Some of the piers are perpendicular, but most of them are oblique to the axis of the bridge, owing to the different directions of the railroad tracks. Their thickness varies according to their loads and clearances but all of them have vertical end faces with side walls battered 1:24. The abutments have slightly battered face walls and side walls. There are eleven spans, one 35 ft. long, one 60 ft. long, and nine varying from 66 to 68 ft. in clear length. The floor of the viaduct is level over the eight center spans, descending over the end spans towards both approaches and the flat segmental arches increase in span from both ends toward the center. The ratio of rise to span increases at the ends so as to provide a corresponding increase of horizontal thrust and make the lateral pressure approximately uniform on both sides of all piers, irrespective of the variation in the spans of the adjacent arches. All arches are reinforced with Melan riveted trusses imbedded in the concrete under the spandrel walls and under the railroad tracks and by intermediate arch ribs made with Thacher bars.



Sidewalk, Curb and Hand Rail.



Arches Reinforced with Trussed Ribs and Thacher Bars.



Sectional Elevations at Crown and Skewback.

The superstructure is proportioned for a dead load consisting of the weight of the concrete assumed at 150 lb. per cubic foot, earth fill at 120 lb., pavements at 110 lb. per square foot, and an allowance of 1,000 lb. per linear foot for the weight of the street car tracks, water and gas pipes and electric wires.

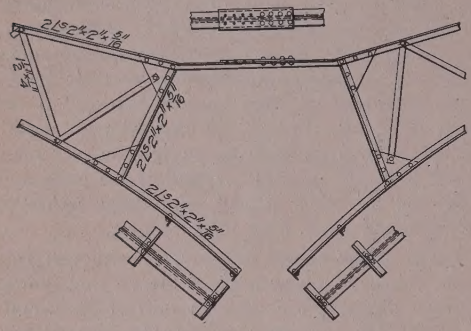
Live load stresses are computed for a uniformly distributed load of 150 lb. per square foot over roadway, and 100 lb. over sidewalks, and for an electric car 55 ft. long weighing 50 tons on each of two tracks 11 ft. apart on centers, each car having two four-wheel trucks with 6-ft. wheel-base, 22 ft. apart on centers. Temperature stresses due to a mean variation of 40 deg. are also provided for.

The maximum stresses allowed for concrete in compression are 500 lb. for the arches, exclusive of temperature stress, and 600 lb. including stresses due to a variation of 40° in temperature amounts which are considered to provide a factor of safety of five when the concrete is six months old. The maximum tension allowed on the concrete is 50 lb. for the arches, exclusive of temperature stresses, and 75 lb. inclusive of temperature stresses, and nothing on the concrete in the slabs, girders, beams, floors, walls and posts. A maximum shear of 75 lb. is allowed in all concrete. The modulus of elasticity is assumed at 1,500,000 lb. for the concrete in the arches, at 2,580,000 lb. for that in the slabs and girders, and 30,000,000 lb. for the steel in the ribs which is calculated to take the entire bending moment of the arch without stressing the concrete and without developing a maximum unit stress of more than 18,000 lb. The minimum rib flange area is 1/150 part of the total cross-sectional area of the arch at the crown and its actual stress when acting in combination with the concrete does not exceed twenty times the stress allowed on the concrete. In slabs, girders, beams, floors and walls subjected to transverse stress the steel is assumed to take the entire tensile stress and to have an area sufficient to equal the compressive strength of concrete made with one part Portland cement, two parts sand, and four parts of broken stone after it is 6 months old.

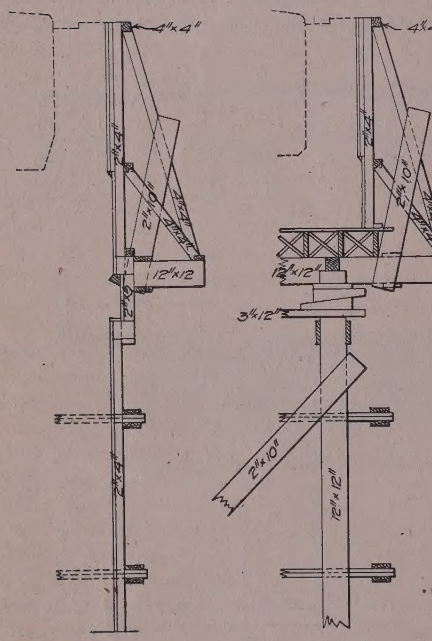
The soil at the site consisted of wet sand 50 ft. or more in depth. All foundations were made with 40-ft. piles driven to a penetration or ¾ in. under the last blow of a 2,240-lb. hammer falling 25 ft., and were loaded to a maximum of 18 tons each. In each pier there are 126 piles, spaced 2½ ft. apart transversely with their upper ends embedded in the concrete footings, 6 ft. deep and 15 ft. wide at the base with an upper surface 9 ft. 9 in. wide to receive the pier masonry 8 ft. 2½ in. wide. Some of the piers are lightened by being pierced with three arches 6 ft. wide and 14 ft. high to the crown.

Seven of the intermediate arches, although not quite duplicates on account of the varying skews of their piers, have a uniform span of 68 ft. and a rise of 7 ft., and their intrados is a three-center curve described with radii of 21.1 and 119⅔ ft. They have a thickness of 17 in. at the crown and about 42 in. on the radial lines at the skewback, and each is reinforced by 20 Thacher ribs spaced 15 in. apart and by 8 Melan ribs 30 in. apart under the spandrel wall and 4 ft. 8 in. apart under the railroad tracks. These Melan ribs are arch girders, each made of four 2x2x5/16-in. flange angles latticed together with 1½x¼-in. bars, and are 12 in. deep at the crown, thus allowing a thickness of 2½ in. of concrete beyond both flanges. At the skewbacks the lower flange angles extend nearly to the center of the pier and have short transverse angles riveted across them to secure bearing in the concrete. The top flange angles are bent horizontal and spliced together at the center point of the pier to make them continuous from end to end of the bridge. The

Thacher ribs are each made with single 1¼-in. bars corresponding to the flanges of the arch girders and are connected by 1½-in. round radial bars 3 ft. apart. The ends of the lower 1¼-in. bars extend nearly to the centers of the piers where they are provided with nuts and washers to afford anchorage in the concrete. The upper bars extend about 1 ft. beyond their point of intersection on the center line of the pier and like the lower bars have nuts and washers at the extremities. Each bar is shipped in three nearly equal lengths, which are spliced together at the site with turnbuckles. The Melan girders are likewise shipped in three sections, provision being made for field splices at the haunches.

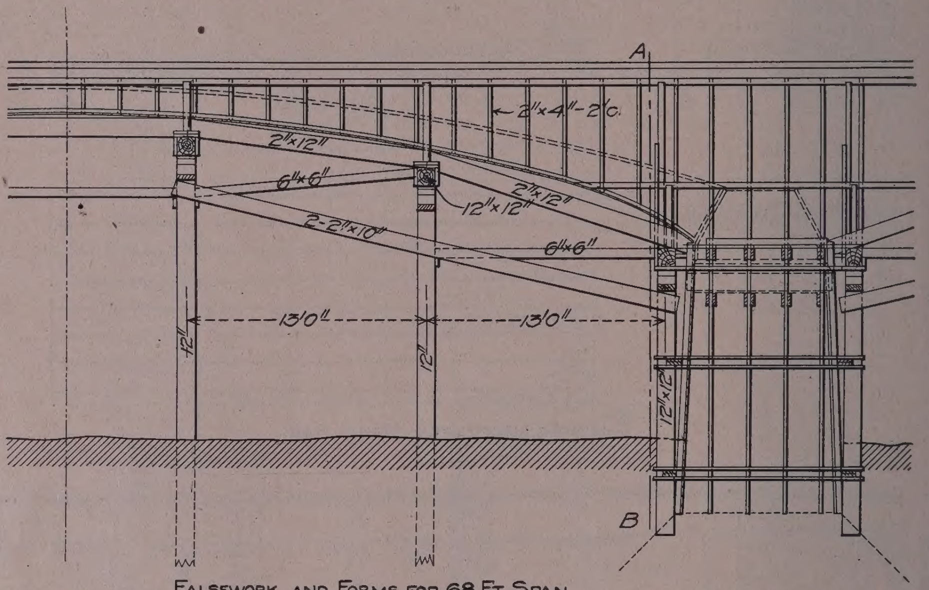


Ribs over Pier.

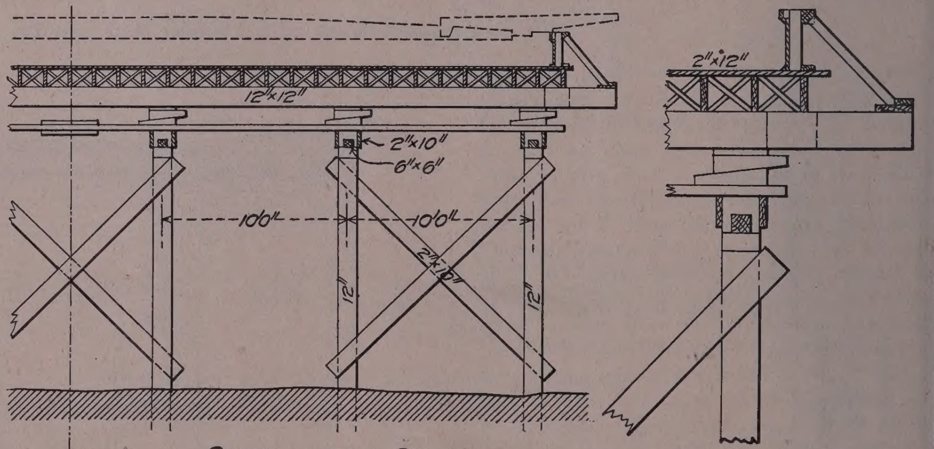


Section thro. Pier Section A-B

Forms for Pier and Spandrels.



Falsework and Forms for 68 Ft Span



Section through Crown

Typical Falsework and Concrete Forms.

The 35-ft. span differs from the long spans in that the soffit is tangent at each end with the face of the pier, giving the appearance of a semi-elliptical curve, and it has a much greater rise and depth at crown in proportion than the other arches, the thickness being 30 in. at the center. The top flanges of its Melan ribs terminate at the centers of the piers and are not spliced to those of the adjacent arches.

The sidewalk cantilevers 3 ft. 9 in. beyond the faces of the spandrel wall on which it rests. The platform is a double balanced cantilever slab with a center bearing 2 ft. wide and a continuous horizontal surface projecting on both sides of it to carry the sidewalk partly over the arch span independent of the fill and partly beyond the outer face. A curb 12 in. deep is made integral with the inner edge of the platform and a concrete parapet 39 in. high is seated on the outer edge. The platform slab is reinforced with ½-in. Thacher rods 6 in. apart and is anchored to the horizontal top of the spandrel wall by ¾-in. vertical bolts 18 in. long and 31 in. apart. The parapet slabs, 2 in. thick, are reinforced by a sheet of Clinton wire cloth with 4x4-in. mesh and No. 10 wire and are stiffened by concrete buttresses 6 in. wide and 2 ft. apart in the clear on the outer face. The sidewalk and parapet slabs were both cast separately in 4-ft. lengths, at the contractor's yards and assembled in position after the spans were completed.

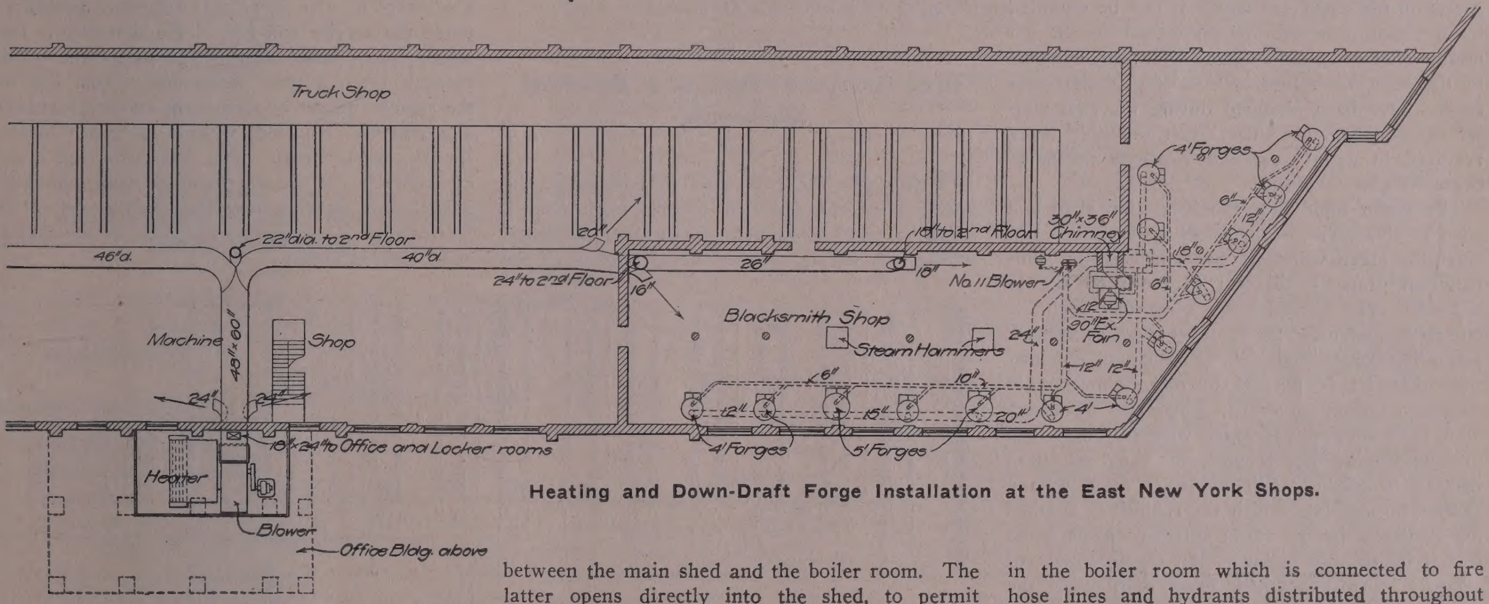
Broken stones, sand and cement were delivered by wagon to one end of the bridge, and hoisted by a bucket elevator to a storage bin of two-days' capacity, delivering by gravity to a cubical concrete mixer. The concrete was discharged into 1-yd. steel buckets carried on a 3-ft. service track parallel to the axis of the bridge and handled by mast and boom derricks located as required. The piers, abutments and foundations were made with 1:3:7 concrete in ordinary forms built in open cofferdams carried down to about 2 ft. below water level. The spandrel and retaining walls were made with 1:2½:6 concrete, and the arches were made with 1:2:4 concrete with 1½-in. broken stones. The parapet slabs were made with 1:2:4 concrete, using very fine broken stone, deposited on a layer of 1:2 cement mortar carefully plastered over the face of the mold. Vulcanite cement was used throughout.

During construction traffic was handled partly by a temporary bridge with short wood and iron spans and partly on the new structure itself, which was built in longitudinal halves for this purpose. It was necessary, however, to shift the traffic back and forth several times during the construction of the work. As far as possible the new piers were built full length at first and the superstructure on them was built on centering of 1-in. lagging carried by 2x12-in. scarf boards 12 in. apart notched over the 12x12-in. caps of the transverse pile trestle bents. The caps were a justable on the pile tops with pairs of foldi wedges, which were not driven out until the se ond half of the bridge was completed and t concrete in it was 30 days old. The centeri for all of the spans and the molds for most the piers were different, but all conformed esse tially to the typical example here illustrate Work on each longitudinal half of each span w commenced at both skewbacks simultaneous and carried on continuously until the arch w completed, two other parties often commenci at the same time at the crown and working bo ways to meet the skewback parties at t haunches. Expansion joints were made in t spandrel wall, cornice and parapet of each ar above the springing line at points one-sixth of t span distant from the springing line.

The total quantities in the bridge includ about 10,000 cu. yd. of concrete, 155 tons of inforcment steel and 1,730 piles. The work v executed by an average force of about 50 m mostly negroes who left and were replaced new men so often as to cause very serious int ruption to the work. The bridge was designed the Concrete-Steel Engineering Co., New Yo which also acted as consulting engineer dur the construction. The cost of the work was frayed jointly by the Atlantic Coast Line, Seaboard Air Line, the Florida East Coast R. the Jacksonville Street Ry. Co., and the city Jacksonville, and it was executed under the di tion of Mr. E. B. Pleasants, chief engineer the Atlantic Coast Line and Mr. Philip Aylett that time bridge engineer of the Seaboard L Mr. Frederick Phillips was resident engineer. work was executed by Shailer & McCormick a cost of about $150,000.

Heating Large Car Inspection Sheds.

Two large car inspection sheds have recently been completed by the Brooklyn Rapid Transit Co. for purposes of inspection and repairs to cars of its elevated divisions. The shops have large interiors with extensive amounts of glass exposure and frequently opened doors, requiring special provisions for heating. One shed is adjacent to the large East New York shop for the eastern division of the elevated lines and the other is adjacent to the large Thirty-sixth St. storage yard of the southern division, which is fitted with an auxiliary shop for light repair work. Both sheds have numerous longitudinal tracks, each fitted with pits for access to the under sides of cars. They have steel frames and brick curtain walls with roofs of the saw-tooth type. The eastern division shed is 110x316 ft. in size, with 18-ft. clear headroom, while the southern division shed is 350 ft. long by 144 ft. wide and has a clear headroom of 20½ ft.



Heating and Down-Draft Forge Installation at the East New York Shops.

Owing to the class of work carried on in these sheds, the problem of heating was a difficult one. In the first place, both sheds are large single areas without partitions and the greater part of the work is caried on in the pits underneath the cars, the part of the building most difficult to heat; and second, not only are there large areas of glass in skylights to be counteracted, but also it is necessary to open the track doors frequently at one end for moving trains. It was accordingly thought desirable to provide for directly warming the pits, so that in spite of open outside doors in extreme weather, the sources of heat should be as near as possible to the workmen. Furthermore, owing to lack of space in the pits for direct radiation and a desire to keep them free from obstructions of all kinds, it was decided to make use of hot blast to the pits.

The two sheds are of approximately the same capacity, that for the eastern division having eight pit tracks designed to accommodate trains of six cars each, or 48 cars total capacity of the shed; the southern division shed has ten tracks, nine of which have pits, although the remaining track and the next adjacent pit track are reserved for special work. The pits are of concrete 49 in. in width, and 48 in. in depth under base of rails, the rails being secured to 8x12-in. wooden stringers anchored to the top of the pit walls. They are all approximately 290 ft. long and have stairways at either end. The pit floors sloped to drainage points and ample lighting is provided by incandescent lamps set in recesses at 10-ft. intervals throughout each pit.

The pit tracks are spaced 13¾ ft. between centers and in alternate spaces between tracks there are building columns, for which reason the distributing ducts of the hot air system were located in the alternate spaces between tracks not occupied by columns. Through these are extended rectangular concrete ducts which distribute the air to the pit outlets. The latter consists of 12-in. tile ducts through the pit walls. These outlets are spaced at 24-ft. intervals on each side of each duct, and each outlet has a damper operated from the pit for regulation of the hot blast. In both sheds eight pit tracks are thus served, the ninth pit track of the southern division shed being utilized for other purposes which made its warming unnecessary.

The hot blast is furnished in both sheds by fans near the rear end of the building, which deliver through cross duct connections under the floor to the longitudinal distributing flues between pit tracks. For the southern division shed an 8-ft. Buffalo pressure blower is installed in an extension to the building on the south side between the main shed and the boiler room. The latter opens directly into the shed, to permit recirculation of inside air, although there are also outside windows that may be opened for taking in outside air. The fan is of the full-housed, downward-delivery type and is belt-driven by a 30-h.-p. motor. It draws its supply through a heater of ten coil sections, having a total of 6,110 lin. ft. of 1-in. pipe, equivalent to a heating surface of 2,100 sq. ft. The fan delivers through a 5x6-ft. connection to the cross duct, which tapers in size as the various longitudinal distributing flues are supplied. The motor is fitted with rheostatic control providing for variation of speed from one-third to full speed, according to the required heating service. The fan, when operated at full speed, has a capacity of 45,600 cu. ft. per minute, at which capacity there is a velocity of flow in the cross duct of 1,500 ft. per minute and an average velocity in the longitudinal ducts of about 1,000 ft. per minute, which is reduced in the delivery outlets to about 600 ft.

The boiler plant at the southern division shop is convenient for supplying steam to the heating coils of the hot blast system, being located alongside the fan room so that the loss in long steam delivery lines is avoided. It occupies a 24x40-ft. detached building with its floor level 16 ft. below that of the fan room floor, being on the level with the machine shop in front of the inspection shed. The side walls of the boiler house are concrete retaining walls, the site having been excavated into an adjoining side hill, and the roof is of concrete arched between 8-in. I-beams spaced 4 ft. on centers. The concrete of the roof has a minimum thickness of 4 in. and is covered with five-ply tar paper and slag. Ample lighting is furnished by an 8x22-ft. hip skylight in the roof. Adjoining the boiler house to the rear is a large coal pocket formed of concrete retaining walls and similar roof covering, hatches being provided in the roof alongside an adjoining side track permitting coal to be dumped directly into the pocket. The pocket is of about the same size as the boiler room and has a storage capacity of over 400 tons.

Steam is furnished by two horizontal return tubular boilers with 16-ft. shells, 60 in. in diameter. They are somewhat larger than is necessary for the heating service, being operated in addition for drying and industrial purposes in the adjoining shop, for which low pressure is used. All condensation from heater coils and radiators in the upper portion of the shop is returned by gravity to the boiler and that from coils in the lower portions of the shop by steam traps. Make-up water is taken from the city system, for which injectors are provided, which are also used for washing and testing purposes. There is in addition an underwriters' fire pump in the boiler room which is connected to fire hose lines and hydrants distributed throughout the shop and yard.

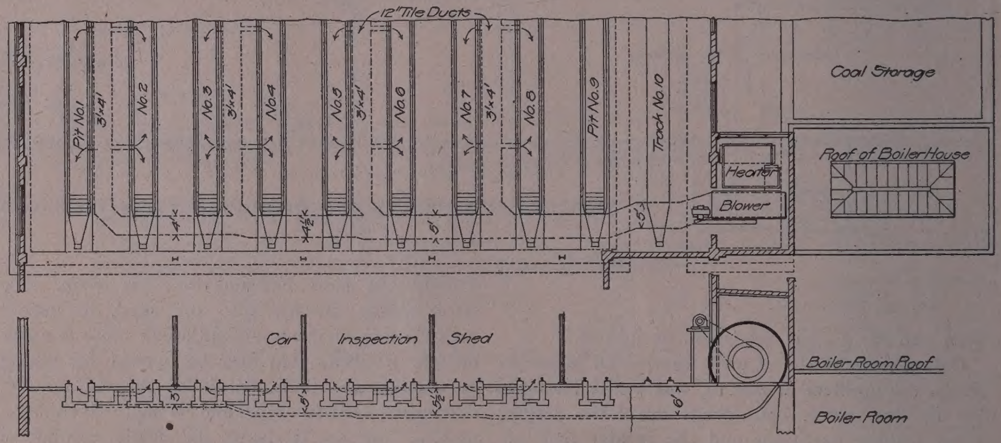
At the eastern division shed the hot blast is supplied to the inspection shed by two 110-in. blowers which are located on elevated platforms in a room at the rear end of the shed adjoining the rear end of the track pits. These fans were built by the New York Blower Co. and each has a capacity of 16,200 cu. ft. per minute. They deliver to the longitudinal distribution ducts by means of a 30x36-in. cross duct, which has a damper at a point between the delivery connections from the two fans, so that either fan may be used to supply half of the building separately through adjoining longitudinal distributing ducts if desired, although normally either one or both fans serve to supply the entire system as a unit. The arrangement of delivery outlets and of control dampers is practically the same in this installation as for the southern division shop, and the velocities of delivery in ducts and from outlets are also practically the same. Air is here similarly recirculated from the shop, although intake connections are provided to permit supplying fresh air from outdoors if desired. The heaters for these fans consist of five-section coils 6 ft. high by 6 ft. long for each, which have a total of 7,560 lin. ft. of 1-in. pipe, equivalent to a heating surface of 2,600 sq. ft. The fans are separately driven by 12½-h.-p. motors fitted for variable speed operation, and the entire outfits are mounted on a steel platform 9 ft. above the floor level of the adjoining room.

In connection with the eastern division inspection shed, there is a large two-story repair shop which is also equipped for indirect heating. It has the usual system of overhead ducts with distributed outlets discharging downward toward the floor, which are supplied by large fans in an annex to the shop at one side. The fan delivers through a 48x60-in. connection to a trunk duct extending down the center of the ceiling of the lower floor, from which, at 50 to 75-ft. intervals, outlets of varying sizes deliver air to the lower floor and through riser flues to registers on the upper floor of the shop. Owing to the large interior volumes air is recirculated from within the shop, except in moderate weather, when it is taken in from the outside. The fan serving this system is a 200-in., three-quarter housed, 30° up-discharge fan which is located, together with its driving motor, in a 16x30-ft. annex to the lower floor of the shop underneath the office extension carried on posts above. The fan is driven by an 8-h.-p. Northern motor and has a 10-section heater containing 10,080 lin. ft. of one-inch pipe, equivalent to a heating surface of 3,475 sq. ft. It has a capacity at a speed of 140 r.p.m. of 60,000 cu. ft. per minute, which at the maximum speed of 165 r.p.m., at which it can be operated by the motor, it will deliver 70,000 cu. ft. per minute. This fan and heater were also supplied by the New York Blower Co. Very satisfactory results have been obtained during the past winter of operation, but little direct radiation being required in certain exposed locations owing to excessive glass exposure.

The steam supply for the inspection shed and shop at this point is furnished by a rubbish incinerator plant, which is maintained by the company on property adjacent to the shop site to the east. The company has a contract with the city of Brooklyn for the removal of ashes, rubbish and other waste material, of which all combustible material is utilized in the incinerator in heating a steam boiler for generation of steam. This incinerator plant, which was fully described in The Engineering Record, for Aug. 25, 1906, contains a 408-h.-p. Stirling boiler fitted with a special furnace into which the rubbish is dumped automatically by an apron conveyor after being sorted by the rag pickers. An ample supply of steam is furnished which more than meets the requirements of the company for this shop plant and adjoining car and office buildings, and a large quantity is sold to outside consumers. Steam is conveyed to the inspection head heaters by a 5-in. line 185 ft. long to the main shop, from which a 3-in. branch extends to the inspection shed. The heater coils are located at a considerable elevation over the boiler plant at the incinerator, so that all condensation is returned to the boiler by gravity.

In connection with the above equipment at the East New York shop an extensive forge equipment of the down-blast type, has been installed by the New York Blower Co., together with pressure supply and exhaust blowers. The blacksmith shop has been made an important feature of the shop plant at this point, its equipment consisting of two steam hammers, several forging machines and bulldozers. For this work 14 down-draft forges of the round steel type have been installed, 12 of which are 4-ft. forges for ordinary work and the other two 5-ft. forges for the heavy work handled in the steam hammers. In the design of this forge equipment it was estimated that 34 lb. of coal will be burned in the 48-in. forges and 55.2 lb. in the 5-ft. forges per hour, for which 113 cu. ft. of air must be delivered to the tuyeres of the smaller forges per minute, and 184 cu. ft. through those of the larger forges. Similarly the exhaust necessary at each forge to effectively remove the smoke through the down-draft hoods is 1,200 cu. ft. and 1,700 cu. ft. per minute for the two sizes of forges.

To accomplish this a No. 11 Peerless down-blast blower was installed for the pressure supply and a 90-in. three-quarter housed up-discharge steel plate fan for exhaust from the down-draft hoods. Both of these blowers are mounted on brackets on the rear wall in elevated position and are motor-driven, the former at 2,000 r.p.m., delivering 1,600 cu. ft. per minute, and the latter at 411 r.p.m., 16,200 cu. ft. per minute. Connections from the blowers to the forges are made under the shop floor, as shown in the accompanying plan of the blacksmith shop, the pressure delivery system consisting of two 12-in. duct lines tapering in size with 4-in. connections to each forge tuyere, while the exhaust system consists of ducts of twice the size with 12-in. exhaust connections to each down-draft hood. The exhaust fan discharges to the atmosphere through a 30x36-in. chimney enclosure, which is carried up to the roof at the rear wall back of the fan. The tuyere connections are all 4-in. branches from the duct to both sizes of forges, which reduce to three-inch tuyeres for the smaller forges with free delivery areas of 2½ sq. in., while four-inch tuyeres are used for the larger forges having 4.13 sq. in. free area.



Hot Blast Heating Equipment, 36th St. Inspection Shed.

Some Commercial Features of Structural Engineering.

On March 5 Mr. Emil Gerber, assistant to the president of the American Bridge Co., read a paper on some commercial features of structural engineering before the Structural Section of the Engineers' Society of Western Pennsylvania, which has attracted much attention. The author's long association with the late George S. Morison and his subsequent connection with structural shops is well known to the older readers of The Engineering Record, and consequently what he has to say on the commercial aspect of a specialty to which his life has been devoted has aroused special interest. The full text of the paper will be found in the Society's "Proceedings" for April, and the following extracts cover only the more important points taken up.

In work involving articles of well-established lines of manufacture, or the use of equally tried processes, it is always advantageous to consult freely with the manufacturer's or contractor's engineers. Such men have probably encountered the problem to be solved, in some form or other, many times to our one, and know its difficulties, weaknesses and anomalies, and have eliminated many fallacies that look good to the eye but are largely illusions. They know also what their machinery can do well and cheaply, and what it cannot do at all, and details which have been worked out by them may at times look peculiar, but be the essence of economy and utility. These men may have hobbies of their own and may sometimes figure a little close, but they are sure to have eliminated the bad for their own good, and a comparison of the experience of several such men along similar lines will enable one readily to winnow the grain from the chaff.

Some years ago the English army required a bridge in Egypt across the Nile at Atbara. The home engineers, accustomed to special designs for each case, even down to making special rolled sections whenever fancy suggested, did not promise the bridge at an early enough date and American competition was invited, on American plans and methods, using sections which were quickly obtainable; the only stipulations being the loads to be carried, quality and stresses of material, and time of delivery. The American contractor built six or seven 140-ft. railroad spans within two months, while it would have taken the English nearly a year. The bridge was erected in relatively equally short time by methods familiar enough to the contractor, but unusual to the English engineers.

The cost of steel bridges to carry the same load over the same length of span varies widely according to the ideas of different designers, while the service and life of the structure is the same. Even when such spans weigh the same there is often a great difference in cost due to the relative degree of refinement on workmanship and material required, without adequate return for the higher cost. The elimination of non-essentials is not only a saving of money in first cost, but it usually saves time in completion of work and it is needless to elaborate on the saying that "time is money."

The specifications for structural steel presented to-day are pretty much alike and conform to what the mills can produce readily and regularly, but occasionally some one asks for some special requirement for ordinary uses, and while ultimately he may get what he asks for at no higher price, he usually has to wait much longer than for standard material. If steel is rolled and does not meet the special requirements, but is of standard quality, there are plenty of people who will take it at once and the replacement consumes weeks of valuable time. Meantime the interest charges on the money already invested run up.

In the design of the details of structures there is as yet no such uniformity as in material. The general plan or layout must of course fit the problem, but the details could be much improved in the line of uniformity and in making as much duplication of parts as possible. Bridges slightly skewed cost more than square ones of a length equal to the gross length of skew spans, and trapezoidal buildings can generally be so divided that most of the connections are at right angles—and that there are many pieces alike. Pieces that are alike should be marked alike, so that the commonest laborer can get with the least labor the piece that is required next. Office convenience in more readily checking pieces with different marks should not overrule the greater simplicity in all subsequent operations of common marking.